

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

- 1 -

## A METHOD OF MODULATING ION CHANNEL FUNCTIONAL ACTIVITY

### FIELD OF THE INVENTION

5 The present invention relates generally to a method of retarding, reducing or otherwise inhibiting viral functional activity and, more particularly, to a method of reducing, retarding or otherwise inhibiting viral functional activity by down-regulating Vpu ion channel functional activity. Even more particularly, the present invention provides a method of treating HIV infection or AIDS by inhibiting Vpu ion channel mediated HIV  
10 replication.

### BACKGROUND OF THE INVENTION

Bibliographic details of the publications alphabetically referred to in this specification are  
15 collected at the end of the description.

Currently, no single treatment method is completely effective against HIV infections. Combination therapies, using drugs that target a number of different aspects of HIV replication, have proven to be the most effective way of ameliorating AIDS symptoms and  
20 prolonging life expectancy (Barry *et al*, 1998; Deeks, 1998; Miles, 1997; Miles, 1998; Moyle *et al*, 1998; Rachlis and Zarowny, 1998; Vell *et al*, 1997; Volberding and Deeks, 1998; and Volberdin, 1998). For example, a measure of success has been achieved with drugs targeting the viral reverse transcriptase and protease enzymes (Miller and Sarver, 1997; Mitsuya, 1992; Moore, 1997; and Thomas and Brady, 1997).

25

The protein Vpu forms an ion channel encoded by HIV and has a number of known roles in the virus life cycle including down-regulation of cell surface expression of the CD4 virus receptor molecule, control of the exit of gp160 from the endoplasmic reticulum and its delivery to the cell surface and regulation of virion budding from the cell surface  
30 membrane. In the absence of Vpu, HIV replication has been shown to be severely retarded in monocytes and macrophages (Balliet *et al*, 1994; and Westervelt *et al*, 1992).

- 2 -

Nevertheless, Vpu has been labelled as an "accessory" protein of HIV because none of its known functions appear to be essential for virus replication *in vitro*.

To improve the prospect of treating and preventing HIV infection, there is an on-going  
5 need to identify molecules capable of inhibiting various aspects of the HIV life cycle. In  
work leading up to the present invention, the inventors have surprisingly determined that  
despite current dogma, viral replication (and in particular HIV replication) can be retarded  
by inhibiting or otherwise down-regulating Vpu ion channel functioning. Further, the  
inventors have also determined that although the drug amiloride has no effect on HIV  
10 replication, amiloride analogues, in which the H<sub>2</sub>N group located at the 5-position of the  
pyrazine has been substituted, inhibit Vpu function and thereby inhibit the continuation of  
the HIV life cycle.

#### SUMMARY OF THE INVENTION

15

Throughout this specification and the claims which follow, unless the context requires  
otherwise, the word "comprise", and variations such as "comprises" and "comprising",  
will be understood to imply the inclusion of a stated integer or step or group of integers or  
steps but not the exclusion of any other integer or step or group of integers or steps.

20

The subject specification contains nucleotide and amino acid sequence information  
prepared using the programme PatentIn Version 2.0, presented herein after the  
bibliography. Each nucleotide or amino acid sequence is identified in the sequence listing  
by the numeric indicator <210> followed by the sequence identifier (e.g. <210> 1,  
25 <210> 2, etc). The length, type of sequence (DNA, protein (PRT), etc) and source  
organism for each nucleotide or amino acid sequence are indicated by information  
provided in the numeric indicator fields <211>, <212> and <213>, respectively.  
Nucleotide and amino sequences referred to in the specification are defined by the  
information provided in numeric indicator field <400> followed by the sequence  
30 identifier (e.g. <400> 1, <400> 2, etc).

- 3 -

One aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting the functional activity of a virus, which virus has infected a mammalian host cell, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate a membrane ion channel  
5 functional activity of said host cell.

Another aspect of the present invention more particularly provides a method of reducing, retarding or otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian host cell, said method comprising administering to said mammal an effective  
10 amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said host cell.

Still another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said  
15 method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said host cell.

Yet another aspect of the present invention provides a method of reducing, retarding or  
20 otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian macrophage, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said macrophage.

25 Still yet another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of an amiloride analogue, or functional equivalent thereof, for a time and under conditions sufficient to inhibit Vpu ion channel functional activity.

- 4 -

A further aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of HMA or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel mediation of HIV replication.

Another further aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of DMA or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel mediation of HIV replication.

Still another further aspect provides a method for the treatment and/or prophylaxis of HIV infection or AIDS in a mammal said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of an HIV infected mammalian host cell, wherein said Vpu functional activity down-regulation reduces, retards or otherwise inhibits the functional activity of said HIV.

Still yet another further aspect provides a method for the treatment and/or prophylaxis of HIV infection or AIDS in a mammal said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of an HIV infected mammalian host cell, wherein said Vpu functional activity down-regulation reduces, retards or otherwise inhibits HIV replication.

Another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting membrane ion channel functional activity in a subject said method comprising administering to said subject an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit membrane ion channel functional activity.

Yet another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting Vpu ion channel functional activity in a mammal said method comprising administering to said mammal an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion  
5 channel functional activity.

Still another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting Vpu ion channel mediation of HIV replication in a mammal said method comprising administering to said mammal an effective amount of an amiloride  
10 analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel functional activity.

Still yet another aspect of the present invention provides an agent useful for reducing, retarding or otherwise inhibiting Vpu ion channel functional activity as hereinbefore  
15 defined.

Still another aspect of the present invention provides a composition for use in reducing, retarding or otherwise inhibiting Vpu ion channel functional activity comprising an agent as hereinbefore defined and one or more pharmaceutically acceptable carriers and/or  
20 diluents.

- 6 -

**BRIEF DESCRIPTION OF THE DRAWINGS**

**Figure 1** is a schematic representation of plasmids used for expression of Vpu in *E. coli*. **A.** The amino acid sequence (<400>1) encoded by the *vpu* open reading frame (ORF) generated by PCR from an HIV-1 strain HXB2 cDNA clone. The *vpu* ORF was cloned in-frame at the 3' end of the GST gene in p2GEX to generate p2GEXVpu (**B**). It was subsequently cloned into pPL451 to produce the plasmid pPL+Vpu (**C**).

**Figure 2** is a photographic representation of the expression and purification of Vpu in *E. coli*. **A.** Western blotting after SDS-PAGE was used to detect expressed Vpu in *E. coli* extracts. Lanes 1-4 contain samples, at various stages of purity, of Vpu expressed from p2GEXVpu: lane 1, GST-Vpu fusion protein isolated by glutathione-agarose affinity chromatography; lane 2, Vpu liberated from the fusion protein by treatment with thrombin; lane 3, Vpu purified by HPLC anion exchange chromatography; lane 4, Vpu after passage through the immunoaffinity column. Lanes 5 and 6, membrane vesicles prepared from 42°C induced cells containing pPL+Vpu or pPL451, respectively. **B.** Silver stained SDS-PAGE gel: lane 1, Vpu purified by HPLC anion exchange chromatography; lane 2, Vpu after passage through the immunoaffinity column.

**Figure 3** is a graphical representation of ion channel activity observed after exposure of lipid bilayers to aliquots containing purified Vpu. In **A** and **B**, the CIS chamber contained 500mM NaCl and the TRANS chamber contained 50mM NaCl; both solutions were buffered at pH 6.0 with 10 mM MES. **B** shows a current versus voltage curve generated from data similar to that shown in **A**.

25

**Figure 4** is a photographic representation of bacterial cross-feeding assays. For all plates, the Met<sup>-</sup>, Pro<sup>-</sup> auxotrophic strain was used to seed a soft agar overlay. Plates **A** and **B** contain minimal drop-out medium minus proline; in plate **C** the medium was minus methionine. To control for viability of the cells in the background lawn, the discs labelled **P** and **M** contained added proline or methionine, respectively. The discs labelled **C** and **V** were inoculated with Met<sup>+</sup>, Pro<sup>+</sup> *E. coli* cells containing the plasmids pPL451 or

- 7 -

pPL+Vpu, respectively. Plates were incubated at 37°C (A and C) or 30°C (B) for two days and photographed above a black background with peripheral illumination from a fluorescent light located below the plate. The images were recorded on a Novaline video gel documentation system. Light halos around the discs labelled P or M on all plates and 5 around the disc labelled V on plate A indicate growth of the background lawn strain.

Figure 5 is a graphical representation of the screening of drugs for potential Vpu channel blockers. The photograph shows a section of a minimal medium-lacking adenine - agarose plate onto which a lawn of XL-1-blue *E. coli* cells containing the Vpu expression plasmid 10 pPLVpu has been seeded. Numbers 6-11 are located at the sites of application of various drugs being tested, which were applied in 3µl drops and allowed to soak into the agarose. The plate was then incubated at 37°C for 48hr prior to being photographed. The background grey shade corresponds to areas of no bacterial growth. The bright circular area around "10" represents bacterial cell growth as a result of application of adenine at 15 that location (positive control). The smaller halo of bacterial growth around "9" is due to the application of 5-(N,N-hexamethylene)-amiloride at that location.

Figure 6 is a graphical representation of the inhibition of Vpu ion channel activity by 5-(N,N-hexamethylene)-amiloride (HMA) in planar lipid bilayers. The three traces 20 represent typical Vpu channel activity observed in the presence of the indicated concentrations of HMA. The solid line indicates the zero current level. Mean currents ( $\pm$  variance), calculated for continuous channel recordings of at least 30 seconds duration, are plotted in the graph for each of the three drug concentrations.

25 Figure 7 is a graphical representation of the effect of HMA on HIV virion production in monocytes and monocyte-derived macrophages. HIV in culture supernatants was assayed at various days post-infection by detection of p24 antigen using a quantitative ELISA method. Solid black bars represent HIV-infected cells exposed to 10µM HMA. Hatched bars are control cells not exposed to drug.



- 8 -

**Figure 8** is a schematic representation of the chemical formula of amiloride, HMA and DMA:  $R=H_2N$ , amiloride:  $R=(CH_3)_2N$ , DMA;  $R=(CH_2)_6N$ , HMA.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The present invention is predicated, in part, on the surprising determination that the replication of viruses which cause a host cell to express a Vpu ion channel, in particular  
5 HIV, can be retarded by inhibiting the functioning of this ion channel. Further, although amiloride has no effect on HIV replication, amiloride analogues are able to inhibit the HIV life cycle by inhibiting Vpu ion channel functioning. This determination now permits the use of agents such as, but not limited to, amiloride analogues as anti-viral agents for the therapy and prophylaxis of viral conditions.

10

Accordingly, one aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting the functional activity of a virus, which virus has infected a mammalian host cell, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate a  
15 membrane ion channel functional activity of said host cell.

Reference to "membrane ion channel" should be understood as a reference to a structure which transports ions across a membrane. The present invention extends to ion channels which may function by means such as passive, osmotic, active or exchange transport. The  
20 ion channel may be formed by intracellular or extracellular means. For example, the ion channel may be an ion channel which is naturally formed by a cell to facilitate its normal functioning. Alternatively, the ion channel may be formed by extracellular means. Extracellular means would include, for example, the formation of ion channels due to introduced chemicals, drugs or other agents such as ionophores or due to the functional  
25 activity of viral proteins encoded by a virus which has entered a cell. Preferably, the ion channel of the present invention is an ion channel which results from the infection of a cell with HIV and, more particularly, the ion channel is formed by the HIV protein Vpu (referred to herein as a "Vpu ion channel").

30 The ion channels which are the subject of the present invention facilitate the transport of ions across membranes. Said membrane may be any membrane and is not limited to the

outer cell wall plasma membrane. Accordingly, "membrane" encompasses the membrane surrounding any cellular organelle, such as the Golgi apparatus and endoplasmic reticulum, the outer cell membrane, the membrane surrounding any foreign antigen which is located within the cell (for example, a viral envelope) or the membrane of a foreign  
5 organism which is located extracellularly. The membrane is typically, but not necessarily, composed of a fluid lipid bilayer. The subject ion channel may be of any structure. For example, the Vpu ion channel is formed by Vpu which is an integral membrane protein encoded by HIV-1 which associates with, for example, the Golgi and endoplasmic reticulum membranes of infected cells. Reference hereinafter to "Vpu ion channels"  
10 should be read as including reference to all other ion channels.

Accordingly, the present invention more particularly provides a method of reducing, retarding or otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian host cell, said method comprising administering to said mammal an effective  
15 amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said host cell.

Reference to "HIV" should be understood as a reference to any HIV strain and including homologues and mutants.  
20

Without limiting the present invention in any way, Vpu is a protein comprising approximately 80 amino acids with an N-terminal transmembrane anchor and a hydrophilic cytoplasmic C-terminal domain. The C-terminal domain typically comprises a 12 amino acid sequence that is conserved and contains two serine residues which are phosphorylated  
25 (Schubert *et al*, 1994 and Friborg *et al*, 1995). Vpu is an integral membrane protein encoded by HIV-1. It associates with the Golgi and endoplasmic reticulum membranes in infected cells, but has not been detected in the viral envelope nor in the plasma membrane of cells except when artificially over-expressed (Schubert *et al*, 1996a). without limiting the present invention in any way, Vpu has the capacity to form homo-oligomers, but the  
30 exact number of subunits in the native complex is not known. The secondary structure and tertiary fold of the cytoplasmic domain of Vpu has been determined by a combination

of NMR and CD spectroscopy and molecular dynamics calculations (Willbold *et al*, 1997) and reveals two  $\alpha$ -helices separated by a short flexible loop containing the phosphorylated serine residues. Recent structural data for the transmembrane domain (Wray *et al*, 1999) supports the theoretical prediction that the region is  $\alpha$ -helical and indicates a tilt angle of  
5 less than  $30^\circ$  to the bilayer normal. Two molecular dynamics simulation studies have been reported based on the assumption that oligomerisation produces a bundle of  $\alpha$ -helices that spans the membrane (Grice *et al*, 1997; and Moore *et al*, 1998). Both studies favour formation of a pentameric complex. However, using different initial conditions and restraint parameters, different conclusions as to the orientation of the individual helices in  
10 the complex were reached. Thus, the actual structure of the native Vpu complex remains to be determined.

In spite of the fact that Vpu has been shown by the inventors to form ion channels, prior to the advent of the present invention it was not known that ion channel formation by Vpu  
15 was a function which is critical to the life cycle of the HIV virus.

Reference to the "functional activity" of an ion channel should be understood as a reference to any one or more of the functions which an ion channel performs or is involved in. For example, the Vpu protein encoded ion channel, in addition to facilitating  
20 the transportation of  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$  and  $\text{PO}_4^{3-}$ , also plays a role in the degradation of the CD4 molecule in the endoplasmic reticulum. The Vpu protein encoded ion channel is also thought to play a role in mediating the HIV life cycle since inactivating this channel inhibits the HIV life cycle, in particular, the replication of HIV. However, the present invention is not limited to treating HIV infection via the mechanism of inhibiting the HIV  
25 life cycle and, in particular, HIV replication. Rather, the present invention should be understood to encompass any mechanism by which inhibiting Vpu ion channel functional activity acts to reduce, retard or otherwise inhibit HIV viability or functional activity. Said functional activity is preferably mediation of the replication of HIV. In this regard, reference to the "functional activity" of a virus should be understood as a reference to any  
30 one or more of the functions which a virus performs or is involved in. This includes, for

- 12 -

example, viral replication and budding. Preferably, said functional activity is HIV replication.

Reference to the "HIV replication" should be understood to include any one or more stages or aspects of the HIV life cycle, such as inhibiting the assembly or release of HIV virions. Said Vpu mediation of HIV replication may be by direct or indirect means. Said Vpu mediation is by direct means if the Vpu ion channel interacts directly with HIV at any one or more of its life cycle stages. Said Vpu mediation is indirect if it acts on a molecule other than HIV which other molecule either directly or indirectly modulates any one or more aspects or stages of the HIV life cycle. Accordingly, the method of the present invention encompassess the mediation of HIV replication via the induction of a cascade of steps which lead to the mediation of any one or more aspects or stages of the HIV life cycle.

According to this preferred embodiment, the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said host cell.

20

Reference to "down-regulating" ion channel functional activity, and in particular Vpu mediation of HIV replication should be understood as a reference to the partial or complete inhibition of any one or more aspects of said activity by both direct and indirect mechanisms. For example, a suitable agent may interact directly with a Vpu ion channel to prevent HIV replication or, alternatively, may act indirectly to prevent said replication by, for example, interacting with a molecule other than the Vpu ion channel wherein said other molecule interacts with and inhibits the activity of the Vpu ion channel.

The inhibition of ion channel functional activity may be achieved by any suitable method, which would be well known to those skilled in the art, including contacting a virally infected cell with a proteinaceous or non-proteinaceous molecule capable of blocking or

otherwise down-regulating functioning of the subject ion channel. Screening for molecules which block Vpu ion channel activity may be achieved for by any suitable method including, for example, the method disclosed in Example 11. It should also be understood that the down-regulation of ion channel functional activity may be achieved by transfecting  
5 a cell, such as the subject host cell, with a nucleic acid molecule which expresses a molecule capable of blocking or otherwise down-regulating functioning of the subject ion channel. Accordingly, reference to "agent" should be understood as a reference to any proteinaceous or non-proteinaceous molecule, including nucleic acid molecules, which directly or indirectly inhibit Vpu ion channel functional activity. Reference to an "agent"  
10 should be understood to include reference to functional equivalents and derivatives thereof of said agent.

Reference to a "mammalian host cell" infected with HIV should be understood as a reference to any cell which has been infected with HIV. This includes, for example, an  
15 infected CD4<sup>+</sup> cell or an infected monocyte or macrophage. Without limiting the present invention in any way, the ability of HIV-1 to infect and efficiently replicate in macrophages is thought to be essential in AIDS pathogenesis. In fact, it has been suggested that macrophage-tropic HIV isolates may be necessary and sufficient for the development of AIDS. Accordingly, in a preferred embodiment the subject HIV infected  
20 cell is a HIV infected macrophage or monocyte.

According to this preferred embodiment there is provided a method of reducing, retarding or otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian macrophage, said method comprising administering to said mammal an  
25 effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of said macrophage.

In another preferred embodiment there is provided a method of reducing, retarding or otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian  
30 macrophage, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel

- 14 -

functional activity of said monocyte.

In a related aspect, the inventors have also surprisingly determined that analogues of amiloride inhibit Vpu ion channel functional activity. This was an unexpected result due to the *prima facie* incompatible structure of the subject analogue with the Vpu ion channel. Specifically, without limiting the present invention to any one theory or mode of action, amiloride analogues are thought to inhibit HIV viron release from cells by causing the Vpu ion channels to become blocked. This blocking is effected by substituted amiloride but not by unsubstituted amiloride. Unsubstituted amiloride is a pyrazinoylguanidine bearing amino groups on the 3- and 5- positions and a chloro group on the 6- position of the pyrazine ring. However, the present invention should not be understood as limited to analogues of this form of amiloride or functional equivalents thereof. The present invention encompasses analogues of any form of amiloride. For example, other isomeric forms of amiloride. Accordingly, reference to "amiloride analogue" should be understood as a reference to any amiloride molecule which exhibits an addition, deletion or substitution, such as an addition, deletion or substitution of an atom or molecule or changing of the charge of an atom or molecule, at any position but more particularly at any one or more of the 6 positions of the pyrazine ring. Preferably, said amiloride analogue is an amiloride molecule exhibiting a substitution of the amino group at the 5- position of the pyrazine ring.

Accordingly, in a preferred embodiment the present invention provides a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of an amiloride analogue, or functional equivalent thereof, for a time and under conditions sufficient to inhibit Vpu ion channel functional activity.

Preferably, said amiloride analogue comprises a substitution of the amino group at the 5- position of the pyrazine ring or functional equivalent thereof. Even more preferably, said Vpu ion channel functional activity is Vpu ion channel mediation of HIV replication.

Still more preferably, said amiloride analogue is 5-(N,N-Hexamethylene)-Amiloride (referred to herein as "HMA") or 5-(N,N-Dimethyl)-Amiloride (referred to herein as "DMA").

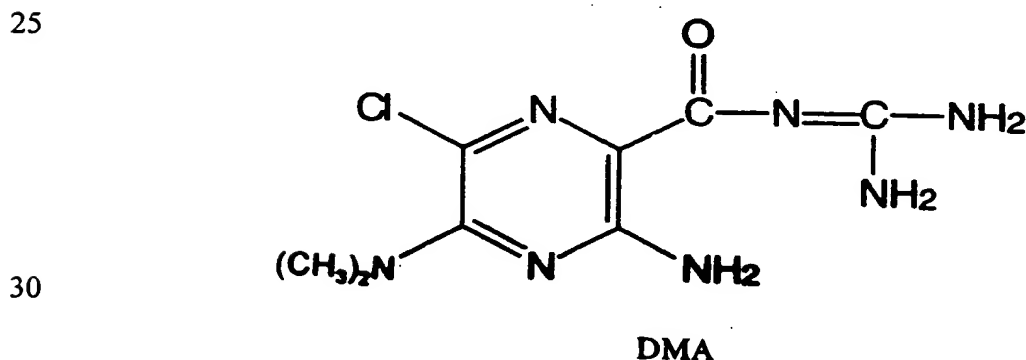
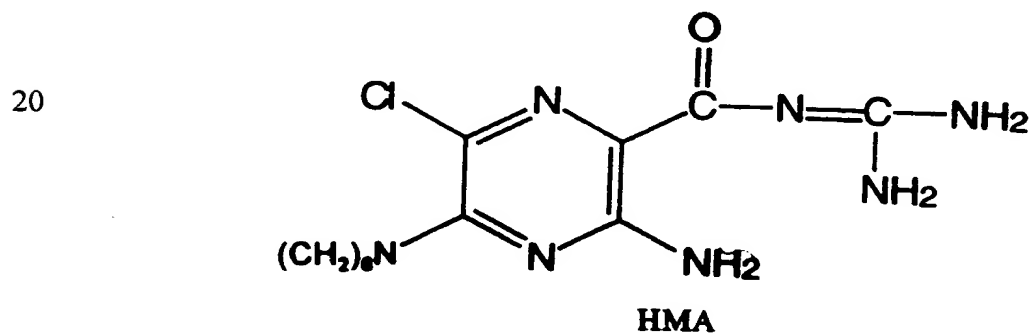
5 According to this preferred embodiment there is provided a method of reducing, retarding or otherwise inhibiting HIV replication, which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of HMA or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel mediation of HIV replication.

10

In another preferred embodiment there is provided a method of reducing, retarding or otherwise inhibiting HIV replication which HIV has infected a mammalian host cell, said method comprising contacting said host cell with an effective amount of DMA or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel

15 mediation of HIV replication.

Most preferably said amiloride analogues comprise the structure:





"Functional equivalents" of amiloride analogues and any other proteinaceous or non-proteinaceous agents which exhibit functional activity equivalent to the amiloride analogues (to the extent that Vpu ion channel functional activity is inhibited or otherwise down-regulated as hereinbefore defined), include functionally active derivatives, fragments, 5 parts, portions and chemical equivalents from natural, synthetic or recombinant sources, including fusion proteins. Chemical equivalents may not necessarily be derived from the subject agent but may share certain conformational similarity. Alternatively, chemical equivalents may be specifically designed to mimic certain physiochemical properties of the agent. Chemical equivalents may be chemically synthesised or may be detected following, 10 for example, natural product screening. Functional equivalents may also possess antagonistic or agonistic properties and the use of such molecules are contemplated by the present invention.

Where the agent or functional equivalent is a proteinaceous molecule, the present 15 invention should be understood to extend to functional derivatives of said proteinaceous molecule. Derivatives include fragments, parts, portions, mutants, and mimetics from natural, synthetic or recombinant sources including fusion proteins. Derivatives may be derived from insertion, deletion or substitution of amino acids. Amino acid insertional derivatives include amino and/or carboxylic terminal fusions as well as intrasequence 20 insertions of single or multiple amino acids. Insertional amino acid sequence variants are those in which one or more amino acid residues are introduced into a predetermined site in the protein although random insertion is also possible with suitable screening of the resulting product. Deletional variants are characterized by the removal of one or more amino acids from the sequence. Substitutional amino acid variants are those in which at 25 least one residue in the sequence has been removed and a different residue inserted in its place. An example of substitutional amino acid variants are conservative amino acid substitutions. Conservative amino acid substitutions typically include substitutions within the following groups: glycine and alanine; valine, isoleucine and leucine; aspartic acid and glutamic acid; asparagine and glutamine; serine and threonine; lysine and arginine; and 30 phenylalanine and tyrosine. Additions to amino acid sequences including fusions with other peptides, polypeptides or proteins.

Homologs of the protein contemplated herein include, but are not limited to, proteins derived from different species.

The derivatives include fragments having particular epitopes of parts of the entire protein  
5 fused to peptides, polypeptides or other proteinaceous or non-proteinaceous molecules. For example, a protein (or a non-proteinaceous molecule) or derivative thereof may be fused to a molecule to facilitate its entry into a cell.

Reference to "derivatives" should also be understood to include reference to analogues.

- 10 Analogues contemplated herein include, but are not limited to, modification to side chains, incorporating of unnatural amino acids and/or their derivatives during peptide, polypeptide or protein synthesis and the use of crosslinkers and other methods which impose conformational constraints on the proteinaceous molecules or their analogues.
- 15 Examples of side chain modifications contemplated by the present invention include modifications of amino groups such as by reductive alkylation by reaction with an aldehyde followed by reduction with  $\text{NaBH}_4$ ; amidination with methylacetimidate; acylation with acetic anhydride; carbamoylation of amino groups with cyanate; trinitrobenzylation of amino groups with 2, 4, 6-trinitrobenzene sulphonic acid (TNBS);  
20 acylation of amino groups with succinic anhydride and tetrahydrophthalic anhydride; and pyridoxylation of lysine with pyridoxal-5-phosphate followed by reduction with  $\text{NaBH}_4$ .

The guanidine group of arginine residues may be modified by the formation of heterocyclic condensation products with reagents such as 2,3-butanedione, phenylglyoxal  
25 and glyoxal.

The carboxyl group may be modified by carbodiimide activation *via* O-acylisourea formation followed by subsequent derivitisation, for example, to a corresponding amide.

- 30 Sulphydryl groups may be modified by methods such as carboxymethylation with iodoacetic acid or iodoacetamide; performic acid oxidation to cysteic acid; formation of a

mixed disulphides with other thiol compounds; reaction with maleimide, maleic anhydride or other substituted maleimide; formation of mercurial derivatives using 4-chloromercuribenzoate, 4-chloromercuriphenylsulphonic acid, phenylmercury chloride, 2-chloromercuri-4-nitrophenol and other mercurials; carbamoylation with cyanate at alkaline  
5 pH.

Tryptophan residues may be modified by, for example, oxidation with N-bromosuccinimide or alkylation of the indole ring with 2-hydroxy-5-nitrobenzyl bromide or sulphenyl halides. Tyrosine residues on the other hand, may be altered by nitration  
10 with tetranitromethane to form a 3-nitrotyrosine derivative.

Modification of the imidazole ring of a histidine residue may be accomplished by alkylation with iodoacetic acid derivatives or N-carboethoxylation with diethylpyrocarbonate.  
15

Examples of incorporating unnatural amino acids and derivatives during protein synthesis include, but are not limited to, use of norleucine, 4-amino butyric acid, 4-amino-3-hydroxy-5-phenylpentanoic acid, 6-aminohexanoic acid, t-butylglycine, norvaline, phenylglycine, ornithine, sarcosine, 4-amino-3-hydroxy-6-methylheptanoic acid, 2-thienyl  
20 alanine and/or D-isomers of amino acids. A list of unnatural amino acid contemplated herein is shown in Table 1.

TABLE 1

	Non-conventional amino acid	Code	Non-conventional amino acid	Code
5	$\alpha$ -aminobutyric acid	Abu	L-N-methylalanine	Nmala
	$\alpha$ -amino- $\alpha$ -methylbutyrate	Mgab	L-N-methylarginine	Nmarg
	aminocyclopropane- carboxylate	Cpro	L-N-methylasparagine	Nmasn
			L-N-methylaspartic acid	Nmasp
10	aminoisobutyric acid	Aib	L-N-methylcysteine	Nmcys
	aminonorbonyl- carboxylate	Norb	L-N-methylglutamine	Nmgln
			L-N-methylglutamic acid	Nmglu
	cyclohexylalanine		Chexa L-N-methylhistidine	Nmhis
	cyclopentylalanine	Cpen	L-N-methylisoleucine	Nmile
15	D-alanine	Dal	L-N-methylleucine	Nmleu
	D-arginine	Darg	L-N-methyllysine	Nmlys
	D-aspartic acid	Dasp	L-N-methylmethionine	Nmmet
	D-cysteine	Dcys	L-N-methylnorleucine	Nmnle
	D-glutamine	Dgln	L-N-methylnorvaline	Nmnva
20	D-glutamic acid	Dglu	L-N-methylornithine	Nmorn
	D-histidine	Dhis	L-N-methylphenylalanine	Nmphe
	D-isoleucine	Dile	L-N-methylproline	Nmpro
	D-leucine	Dleu	L-N-methylserine	Nmser
	D-lysine	Dlys	L-N-methylthreonine	Nmthr
25	D-methionine	Dmet	L-N-methyltryptophan	Nmtrp
	D-ornithine	Dorn	L-N-methyltyrosine	Nmtyr
	D-phenylalanine	Dphe	L-N-methylvaline	Nmval
	D-proline	Dpro	L-N-methylethylglycine	Nmetg
	D-serine	Dser	L-N-methyl-t-butylglycine	Nmtbug
30	D-threonine	Dthr	L-norleucine	Nle
	D-tryptophan	Dtrp	L-norvaline	Nva

	D-tyrosine	Dtyr	$\alpha$ -methyl-aminoisobutyrate	Maib
	D-valine	Dval	$\alpha$ -methyl- $\gamma$ -aminobutyrate	Mgab
	D- $\alpha$ -methylalanine	Dmala	$\alpha$ -methylcyclohexylalanine	Mchexa
	D- $\alpha$ -methylarginine	Dmarg	$\alpha$ -methylcyclopentylalanine	Mcpen
5	D- $\alpha$ -methylasparagine	Dmasn	$\alpha$ -methyl- $\alpha$ -naphthylalanine	Manap
	D- $\alpha$ -methylaspartate	Dmasp	$\alpha$ -methylpenicillamine	Mpen
	D- $\alpha$ -methylcysteine	Dmcys	N-(4-aminobutyl)glycine	Nglu
	D- $\alpha$ -methylglutamine	Dmgln	N-(2-aminoethyl)glycine	Naeg
	D- $\alpha$ -methylhistidine	Dmhis	N-(3-aminopropyl)glycine	Norn
10	D- $\alpha$ -methylisoleucine	Dmile	N-amino- $\alpha$ -methylbutyrate	Nmaabu
	D- $\alpha$ -methylleucine	Dmleu	$\alpha$ -naphthylalanine	Anap
	D- $\alpha$ -methyllysine	Dmlys	N-benzylglycine	Nphe
	D- $\alpha$ -methylmethionine	Dmmet	N-(2-carbamylethyl)glycine	Ngln
	D- $\alpha$ -methylornithine	Dmorn	N-(carbamylmethyl)glycine	Nasn
15	D- $\alpha$ -methylphenylalanine	Dmphe	N-(2-carboxyethyl)glycine	Nglu
	D- $\alpha$ -methylproline	Dmpro	N-(carboxymethyl)glycine	Nasp
	D- $\alpha$ -methylserine	Dmser	N-cyclobutylglycine	Ncbut
	D- $\alpha$ -methylthreonine	Dmthr	N-cycloheptylglycine	Nchep
	D- $\alpha$ -methyltryptophan	Dmtrp	N-cyclohexylglycine	Nchex
20	D- $\alpha$ -methyltyrosine	Dmty	N-cyclodecylglycine	Ncdec
	D- $\alpha$ -methylvaline	Dmval	N-cyclododecylglycine	Ncdod
	D-N-methylalanine	Dnmala	N-cyclooctylglycine	Ncoct
	D-N-methylarginine	Dnmarg	N-cyclopropylglycine	Ncpro
	D-N-methylasparagine	Dnmasn	N-cycloundecylglycine	Ncund
25	D-N-methylaspartate	Dnmasp	N-(2,2-diphenylethyl)glycine	Nbhm
	D-N-methylcysteine	Dnmcys	N-(3,3-diphenylpropyl)glycine	Nbhe
	D-N-methylglutamine	Dnmgln	N-(3-guanidinopropyl)glycine	Narg
	D-N-methylglutamate	Dnmglu	N-(1-hydroxyethyl)glycine	Nthr
	D-N-methylhistidine	Dnmhis	N-(hydroxyethyl)glycine	Nser
30	D-N-methylisoleucine	Dnmile	N-(imidazolylethyl)glycine	Nhis
	D-N-methylleucine	Dnmleu	N-(3-indolylyethyl)glycine	Nhtrp

	D-N-methyllysine	Dnmlys	N-methyl- $\gamma$ -aminobutyrate	Nmgabu
	N-methylcyclohexylalanine	Nmchexa	D-N-methylmethionine	Dnmmt
	D-N-methylornithine	Dnmorn	N-methylcyclopentylalanine	Nmcpn
	N-methylglycine	Nala	D-N-methylphenylalanine	Dnmphe
5	N-methylaminoisobutyrate	Nmaib	D-N-methylproline	Dnmpro
	N-(1-methylpropyl)glycine	Nile	D-N-methylserine	Dnmser
	N-(2-methylpropyl)glycine	Nleu	D-N-methylthreonine	Dnmthr
	D-N-methyltryptophan	Dnmtrp	N-(1-methylethyl)glycine	Nval
	D-N-methyltyrosine	Dnmtyr	N-methyl- <i>n</i> -naphthylalanine	Nmanap
10	D-N-methylvaline	Dnmval	N-methylpenicillamine	Nmpen
	$\gamma$ -aminobutyric acid	Gabu	N-( <i>p</i> -hydroxyphenyl)glycine	Nhtyr
	L- <i>t</i> -butylglycine	Tbug	N-(thiomethyl)glycine	Ncys
	L-ethylglycine	Etg	penicillamine	Pen
	L-homophenylalanine	Hphe	L- $\alpha$ -methylalanine	Mala
15	L- $\alpha$ -methylarginine	Marg	L- $\alpha$ -methylasparagine	Masn
	L- $\alpha$ -methylaspartate	Masp	L- $\alpha$ -methyl- <i>t</i> -butylglycine	Mtbug
	L- $\alpha$ -methylcysteine	Mcys	L-methylethylglycine	Metg
	L- $\alpha$ -methylglutamine	Mgln	L- $\alpha$ -methylglutamate	Mglu
	L- $\alpha$ -methylhistidine	Mhis	L- $\alpha$ -methylhomophenylalanine	Mhphe
20	L- $\alpha$ -methylisoleucine	Mile	N-(2-methylthioethyl)glycine	Nmet
	L- $\alpha$ -methyllleucine	Mleu	L- $\alpha$ -methyllysine	Mlys
	L- $\alpha$ -methylmethionine	Mmet	L- $\alpha$ -methylnorleucine	Mnle
	L- $\alpha$ -methylnorvaline	Mnva	L- $\alpha$ -methylornithine	Morn
	L- $\alpha$ -methylphenylalanine	Mphe	L- $\alpha$ -methylproline	Mpro
25	L- $\alpha$ -methylserine	Mser	L- $\alpha$ -methylthreonine	Mthr
	L- $\alpha$ -methyltryptophan	Mtrp	L- $\alpha$ -methyltyrosine	Mtyr
	L- $\alpha$ -methylvaline	Mval	L-N-methylhomophenylalanine	Nmhph
	N-(N-(2,2-diphenylethyl)	Nnbhm	N-(N-(3,3-diphenylpropyl)	Nnbhe
	carbamylmethyl)glycine		carbamylmethyl)glycine	
30	1-carboxy-1-(2,2-diphenyl-Nmbc			
	ethylamino)cyclopropane			

---

Crosslinkers can be used, for example, to stabilise 3D conformations, using homo-bifunctional crosslinkers such as the bifunctional imido esters having  $(CH_2)_n$  spacer groups with  $n=1$  to  $n=6$ , glutaraldehyde, N-hydroxysuccinimide esters and hetero-  
5 bifunctional reagents which usually contain an amino-reactive moiety such as N-hydroxysuccinimide and another group specific-reactive moiety.

The subject of the viral inhibition is generally a mammal such as but not limited to human, primate, livestock animal (e.g. sheep, cow, horse, donkey, pig), companion  
10 animal (e.g. dog, cat), laboratory test animal (e.g. mouse, rabbit, rat, guinea pig, hamster), captive wild animal (e.g. fox, deer). Preferably, the subject is a human or primate. Most preferably, the subject is a human.

The method of the present invention is useful in the treatment and prophylaxis of HIV  
15 infection and AIDS. For example, the down-regulation of Vpu ion channel functional activity may be effected in subjects known to be infected with HIV in order to prevent replication of HIV thereby preventing the onset of AIDS. Alternatively, the method of the present invention may be used to reduce serum viral load or to alleviate AIDS symptoms.

20 The method of the present invention may be particularly useful either early in HIV infection to prevent the establishment of a viral reservoir in cell types such as monocytes and macrophages or as a prophylactic treatment to be applied immediately prior to or for a period after exposure to a possible source of HIV infection.

25 Accordingly, in another aspect there is provided a method for the treatment and/or prophylaxis of HIV infection or AIDS in a mammal said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of an HIV  
30 infected mammalian host cell, wherein said Vpu functional activity down-regulation reduces, retards or otherwise inhibits the functional activity of said HIV.

More particularly, the present invention provides a method for the treatment and/or prophylaxis of HIV infection or AIDS in a mammal said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of an HIV  
5 infected mammalian host cell, wherein said Vpu functional activity down-regulation reduces, retards or otherwise inhibits HIV replication.

Reference to "an effective amount" means an amount necessary to at least partly attain the desired response.

10

Reference herein to "treatment" and "prophylaxis" is to be considered in its broadest context. The term "treatment" does not necessarily imply that a mammal is treated until total recovery. Similarly, "prophylaxis" does not necessarily mean that the subject will not eventually contract a disease condition. Accordingly, treatment and prophylaxis  
15 include amelioration of the symptoms of a particular condition or preventing or otherwise reducing the risk of developing a particular condition. The term "prophylaxis" may be considered as reducing the severity of onset of a particular condition. "Treatment" may also reduce the severity of an existing condition or the frequency of acute attacks.

20 Preferably said agent is an amiloride analogue or functional equivalent thereof. Even more preferably, said amiloride analogue is HMA or DMA.

In accordance with this method, more than one type of agent may be administered or the agent may be co-administered with another molecule such as a known anti-viral  
25 compound or molecule. By "co-administered" is meant simultaneous administration in the same formulation or in two different formulations via the same or different routes or sequential administration by the same or different routes. By "sequential" administration is meant a time difference of from seconds, minutes, hours or days between the administration of the two types of an amiloride analogue or the amiloride analogue and  
30 the known anti-viral compound or molecule. The subject agent and known anti-viral compound or molecule may be administered in any order.



Routes of administration include but are not limited to intravenously, intraperitoneally, subcutaneously, intracranially, intradermally, intramuscularly, intraocularly, intrathecally, intracerebrally, intranasally, by infusion, orally, rectally, *via* iv drip, patch and implant. Intravenous routes are particularly preferred.

5

The present invention further extends to the use of the subject agents in the manufacture of a medicament for the therapeutic or prophylactic treatment of HIV infection or AIDS in a mammal wherein said agent reduces, retards or otherwise inhibits Vpu ion channel functional activity of an HIV infected cell.

10

Preferably said functional activity is mediation of HIV replication.

Most preferably said agent is an amiloride analogue or functional equivalent thereof and still more preferably HMA or DMA or functional equivalent thereof.

15

As detailed previously, the inventors have surprisingly determined that although amiloride has no effect on Vpu ion channel functional activity, amiloride analogues are able to block functional activity.

20 Accordingly, another aspect of the present invention provides a method of reducing, retarding or otherwise inhibiting membrane ion channel functional activity in a subject said method comprising administering to said subject an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit membrane ion channel functional activity.

25

More particularly, the present invention provides a method of reducing, retarding or otherwise inhibiting Vpu ion channel functional activity in a mammal said method comprising administering to said mammal an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu  
30 ion channel functional activity.

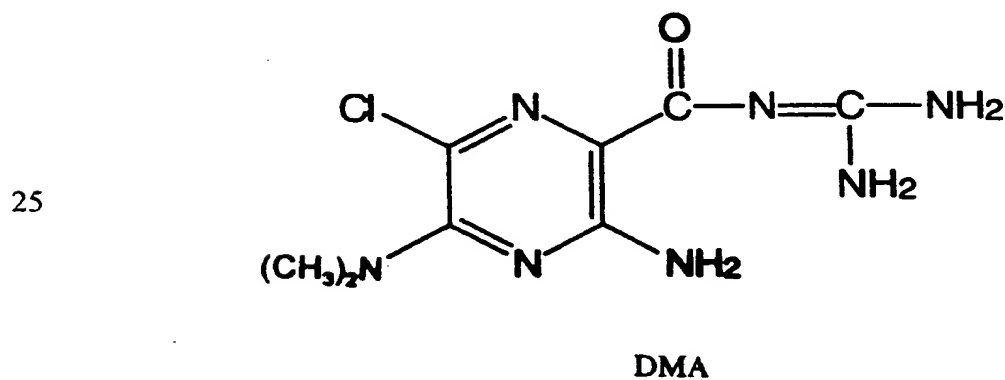
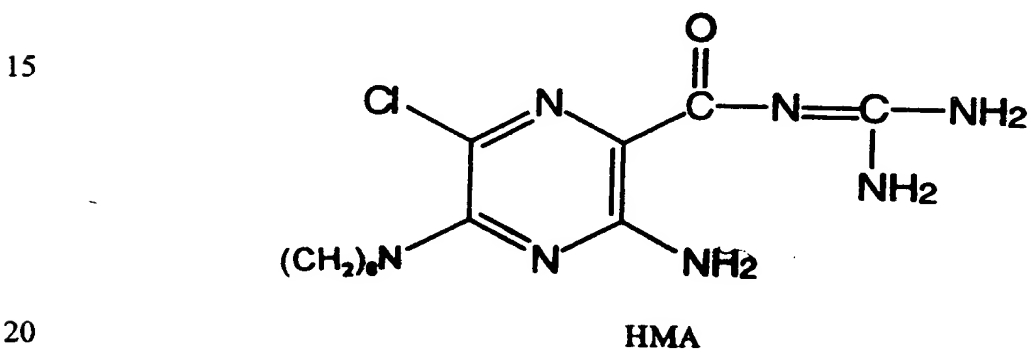
Still more preferably, the present invention provides a method of reducing, retarding or otherwise inhibiting Vpu ion channel mediation of HIV replication in a mammal said method comprising administering to said mammal an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to

5 inhibit Vpu ion channel functional activity.

Preferably, said amiloride analogue comprises a substitution of the amino group of the 5-position of the pyrazine ring or functional equivalent thereof.

10 Even more preferably, said amiloride analogue is HMA or DMA.

Most preferably, said amiloride analogues comprise the structure:



Yet another aspect of the present invention provides an agent useful for reducing, retarding or otherwise inhibiting Vpu ion channel functional activity as hereinbefore defined.

- 5 Preferably said functional activity is mediation of HIV replication.

Most preferably said agent is an amiloride analogue or functional equivalent thereof and even more particularly said agent is HMA or DMA or functional equivalent thereof.

- 10 Still another aspect of the present invention provides a composition for use in reducing, retarding or otherwise inhibiting Vpu ion channel functional activity comprising an agent as hereinbefore defined and one or more pharmaceutically acceptable carriers and/or diluents. The composition may also comprise two different types of agents or an agent and a known anti-viral compound or molecule.

15

Preferably said inhibition of ion channel functional activity is inhibition of Vpu ion channel mediation of HIV replication.

- Compositions suitable for injectable use include sterile aqueous solutions (where water  
20 soluble) and sterile powders for the extemporaneous preparation of sterile injectable solutions. They must be stable under the conditions of manufacture and storage and must be preserved against the contaminating action of microorganisms such as bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol and liquid polyethylene  
25 glycol, and the like), suitable mixtures thereof and vegetable oils. The preventions of the action of microorganisms can be brought about by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars or sodium chloride. Prolonged absorption of the injectable compositions can be brought  
30 about by the use in the compositions of agents delaying absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions are prepared by incorporating the active compounds in the required amount in the appropriate solvent with various of the other ingredients enumerated above, as required, followed by, for example, filter sterilization or sterilization by other appropriate means. Dispersions are also contemplated and these  
5 may be prepared by incorporating the various sterilized active ingredients into a sterile vehicle which contains the basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, a preferred method of preparation includes vacuum drying and the freeze-drying technique which yield a powder of the active ingredient plus any additional  
10 desired ingredient from a previously sterile-filtered solution.

When the active ingredients are suitably protected, they may be orally administered, for example, with an inert diluent or with an assimilable edible carrier, or it may be enclosed in hard or soft shell gelatin capsule, or it may be compressed into tablets. For oral  
15 therapeutic administration, the active compound may be incorporated with excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups, wafers, and the like. Such compositions and preparations should contain at least 1% by weight of active compound. The percentage of the compositions and preparations may, of course, be varied and may conveniently be between about 5 to  
20 about 80% of the weight of the unit. The amount of active compound in such therapeutically useful compositions is such that a suitable dosage will be obtained. Preferred compositions or preparations according to the present invention are prepared so that an oral dosage unit form contains between about 0.1mg and 2000 mg of active compound.

25

The tablets, troches, pills, capsules and the like may also contain the components as listed hereafter: A binder such as gum, acacia, corn starch or gelatin; excipients such as dicalcium phosphate; a disintegrating agent such as corn starch, potato starch, alginic acid and the like; a lubricant such as magnesium stearate; and a sweetening agent such a  
30 sucrose, lactose or saccharin may be added or a flavouring agent such as peppermint, oil of wintergreen, or cherry flavouring. When the dosage unit form is a capsule, it may

contain, in addition to materials of the above type, a liquid carrier. Various other materials may be present as coatings or to otherwise modify the physical form of the dosage unit. For instance, tablets, pills, or capsules may be coated with shellac, sugar or both. A syrup or elixir may contain the active compound, sucrose as a sweetening agent, methyl and propylparabens as preservatives, a dye and flavouring such as cherry or orange flavour. Any material used in preparing any dosage unit form should be pharmaceutically pure and substantially non-toxic in the amounts employed. In addition, the active compound(s) may be incorporated into sustained-release preparations and formulations.

10

The present invention also extends to forms suitable for topical application such as creams, lotions and gels. In such forms, the anti-clotting peptides may need to be modified to permit penetration of the surface barrier.

15 Pharmaceutically acceptable carriers and/or diluents include any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents and the like. The use of such media and agents for pharmaceutically active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active ingredient, use thereof in the therapeutic compositions is contemplated. Supplementary active ingredients can also be incorporated into the compositions.

It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the mammalian subjects to be treated; each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the novel dosage unit forms of the invention are dictated by and directly dependent on (a) the unique characteristics of the active material and the particular therapeutic effect to be achieved and (b) the limitations inherent in the art of compounding.

25  
30

- 29 -

Effective amounts contemplated by the present invention will vary depending on the severity of the pain and the health and age of the recipient. In general terms, effective amounts may vary from 0.01 ng/kg body weight to about 100 mg/kg body weight. Alternative amounts include for about 0.1 ng/kg body weight about 100 mg/kg body weight or from 1.0 ng/kg body weight to about 80 mg/kg body weight.

Further features of the present invention are more fully described in the following Examples. It is to be understood, however, that the detailed description is included solely for the purpose of exemplifying the present invention. It should not be understood in any way as a restriction on the broad description of the invention as set out above.

## EXAMPLE 1

### Construction of recombinant plasmids p2GEXVpu and pPLVpu

The open reading frame encoding Vpu (Fig 1a) was amplified by PCR from a cDNA  
5 clone of an Nde 1 fragment of the HIV-1 genome (isolate HXB2, McFarlane Burnet  
Centre, Melbourne, Australia). Native *Pfu* DNA polymerase (Stratagene; 0.035 U/ $\mu$ l)  
was chosen to catalyse the PCR reaction to minimise possible PCR introduced errors by  
virtue of the enzyme's proofreading activity. The 5', sense, primer  
AGTAGGATCCATGCAACCTATACC (<400>2) introduces a BamH1 site  
10 (underlined) for cloning in-frame with the 3' end of the GST gene in p2GEX (41). This  
primer also repairs the start codon (bold T replaces a C) of the *vpu* gene which is a  
threonine codon in the HXB2 isolate. The 3', antisense, primer  
TCTGGAATTCTACAGATCAT CAAC (<400>3) introduces an EcoR1 site  
(underlined) to the other end of the PCR product to facilitate cloning. After 30 cycles of  
15 94°C for 45 sec, 55°C for 1 min and 72°C for 1 min in 0.5 ml thin-walled eppendorf  
tubes in a Perkin-Elmer thermocycler, the 268bp fragment was purified, digested with  
BamH1 and EcoR1 and ligated to p2GEX prepared by digestion with the same two  
enzymes. The resultant recombinant plasmid is illustrated in Fig 1b. The entireVpu  
open reading frame and the BamH1 and EcoR1 ligation sites were sequenced by cycle  
20 sequencing, using the Applied Biosystems dye-terminator kit, to confirm the DNA  
sequence.

To prepare the Vpu open reading frame for insertion into the pPL451 expression  
plasmid, p2GEXVpu was first digested with BamH1 and the 5' base overhang was filled  
25 in the Klenow DNA polymerase in the presence of dNTPs. The Vpu-encoding fragment  
was then liberated by digestion with EcoR1, purified from an agarose gel and ligated into  
pPL451 which had been digested with Hpa1 and EcoR1. Western blots subsequently  
confirmed that the pPLVpu construct (Fig 1c) expressed Vpu after induction of cultures  
at 42°C to inactivate the cI857 repressor of the PR and PL promoters.

## EXAMPLE 2

### Raising polyclonal antibodies for immuno-identification of Vpu

A peptide CALVEMGVEMGGHHAPWDVDDL (<400>4) corresponding to the C-terminal 20 amino acid residues of Vpu was synthesised in the Biomolecular Resource Facility (ANU, Australia) using an Applied Biosystems model 477A machine. A multiple antigenic peptide (MAP) was prepared (Lu *et al*, 1991) by coupling the peptide to a polylysine core via the N-terminal cysteine residue. The MAP was used to immunise rabbits for production of polyclonal antisera recognising the C-terminus of Vpu. For immunisations 1mg of MAP peptide was dissolved in 1.25ml of MTPBS (16mM Na<sub>2</sub>HPO<sub>4</sub>, 4mM NaHPO<sub>4</sub>, 150mM NaCl pH 7.3) and emulsified with 1.25ml of Freund's complete adjuvant and injected at multiple subcutaneous sites on the rabbit's back. Booster injections used Freund's incomplete adjuvant and were spaced at least 4 weeks apart with serum being sampled 10-14 days after injections.

15

## EXAMPLE 3

### Techniques involving the antibodies

Peptide-specific antibodies were purified from rabbit sera using an Immunopure™ Ag/Ab Immobilisation kit from Pierce. The synthetic peptide was cross-linked via its N-terminal cysteine to the matrix of a 5ml Sulfo Link™ column according to the kit's instructions, 2.5ml of Vpu immunoreactive serum was added to 20ml of Tris buffer (10mM pH 7.4) and passed through the peptide column three times to maximise exposure of the antibodies to the peptide. The column was washed with 20ml of 10mM Tris pH 7.4 followed by 20ml of the same buffer supplemented with 500mM NaCl. The bound antibodies were eluted in 5ml of 100mM glycine/150mM NaCl, pH 2.5 and eluents were immediately neutralised by addition of 250μl of 1M Tris pH 9.0 and dialysed overnight against MTPBS.

30 An anti-Vpu immunoaffinity column was constructed by covalently cross-linking 200μg of purified antibody to 100μl of protein A agarose beads (Schleicher and Schuell) using



the bifunctional cross-linking reagent dimethylpimelimidate as described previously (Harlow and Lane, 1988).

Immunoprecipitation of Vpu was performed by incubation of samples in the presence of approximately 5-fold excess of purified antibody (room temperature for 1 hr) followed by addition of excess protein-A agarose, incubation for 30 min, and centrifugation to pellet the Vpu-antibody complexes. The supernatant, which was subsequently used as a control in the electrophysiological bilayer experiments, was tested by western blotting to confirm that Vpu had been completely removed. Protein samples were electrophoresed on homogeneous 18% SDS polyacrylamide gels using a minigel apparatus and prepoured gels (Novex). Samples were treated with SDS (3.2% final) and mercaptoethanol (0.8% final) at 60°C for 5 min before loading onto gels. Protein bands were visualised either with Coomassie brilliant blue R250 or by silver staining.

For western blotting, proteins were transferred from acrylamide gels to PVDF membranes using a semi-dry transfer apparatus (Pharmacia LKB). Vpu was detected after consecutive reactions of the blots with polyclonal antiserum or purified antibodies, goat anti-rabbit alkaline phosphatase conjugate and Western Blue™ stabilised substrate (Promega).

20

#### EXAMPLE 4

##### PURIFICATION OF RECOMBINANT VPU FROM E. COLI

Cultures of *E. coli* strain XL1-blue cells containing p2GEXVpu were grown at 30°C with vigorous aeration in LB medium supplemented with glucose (6g/L) and ampicillin (50mg/L) to a density of approximately 250 Klett units, at which time IPTG was added to a final concentration of 0.01mM and growth was continued for a further 4hr. The final culture density was approximately 280 Klett units. Since early experiments revealed that the majority of expressed GST-Vpu fusion protein was associated with both the cell debris and membrane fractions, the method of Varadhachary and Maloney (Varadhachary and Maloney, 1990) was adopted to isolate osmotically disrupted cell ghosts (combining both cell debris

30

and membrane fractions) for the initial purification steps. Cells were harvested, washed, weighed and resuspended to 10ml/g wet weight in MTPBS containing DTT (1mM) and  $MgCl_2$  (10mM). Lysozyme (0.3 mg/ml; chicken egg white; Sigma) was added and incubated on ice for 30 min with gentle agitation followed by 5 min at 37°C. The osmotically sensitised cells were pelleted at 12,000g and resuspended to the original volume in water to burst the cells. The suspension was then made up to 1xMTPBS/DTT using a 10x buffer stock and the ghosts were isolated by centrifugation and resuspended in MTPBS/DTT to which was then sequentially added glycerol (to 20% wt/vol) and CHAPS (to 2% wt/vol) to give a final volume of one quarter the original volume. This mixture was stirred on ice for 1 hr and then centrifuged at 400,000g for 1hr to remove insoluble material. The GST-Vpu fusion protein was purified from the detergent extract by affinity chromatography on a glutathione agarose resin (Sigma). The resin was thoroughly washed in 50mM Tris pH 7.5 containing glycerol (5%), DTT (1mM), and CHAPS (0.5%) (Buffer A) and then the Vpu portion of the fusion protein was liberated and eluted from the resin-bound GST by treatment of a 50% (v/v) suspension of the beads with human thrombin (100U/ml; 37°C for 1hr). PMSF (0.5mM) was added to the eluant to eliminate any remaining thrombin activity. This Vpu fraction was further purified on a column of MA7Q anion exchange resin attached to a BioRad HPLC and eluted with a linear NaCl gradient (0-2M) in buffer A.

The Vpu was purified to homogeneity - as determined on silver stained gels - on an immunoaffinity column as follows: HPLC fractions containing Vpu were desalted on a NAP column (Pharmacia) into buffer A and then mixed with the antibody-agarose beads for 1hr at room temperature. The beads were washed thoroughly and Vpu was eluted by increasing the salt concentration to 2M. Protein was quantitated using the BioRad dye-binding assay.

### EXAMPLE 5

#### RECONSTITUTION OF VPU IN PHOSPHOLIPID VESICLES

Proteoliposomes containing Vpu were prepared by the detergent dilution method (New, 1990). A mixture of lipids (PE:PC:PS; 5:3:2; 1mg total lipid) dissolved in chloroform was

- 34 -

dried under a stream of nitrogen gas and resuspended in 0.1 ml of potassium phosphate buffer (50mM pH 7.4) containing DTT (1mM). A 25 $\mu$ l aliquot containing purified Vpu was added, followed by octylglucoside to a final concentration of 1.25% (wt/vol). This mixture was subject to three rounds of freezing in liquid nitrogen, thawing and sonication in a bath-  
5 type sonicator (20-30 sec) and was then rapidly diluted into 200 volumes of the potassium phosphate buffer. Proteoliposomes were collected by centrifugation at 400,000g for 1hr and resuspended in approximately 150 $\mu$ l of phosphate buffer.

### EXAMPLE 6

10

#### ASSAYING ION CHANNEL ACTIVITY

Purified Vpu was tested for its ability to induce channel activity in planar lipid bilayers using standard techniques as described elsewhere (Miller, 1986; and Piller *et al*, 1996). The solutions in the CIS and TRANS chambers were separated by a Delrin<sup>TM</sup> plastic wall  
15 containing a small circular hole of approximately 100 $\mu$ m diameter across which a lipid bilayer was painted so as to form a high resistance electrical seal. Bilayers were painted from a mixture (8:2) of palmitoyl-oleoyl-phosphatidyl-ethanolamine and palmitoyl-oleoyl-phosphatidyl-choline (Avanti Polar Lipids, Alabaster, Alabama) in n-decane. The solutions in the two chambers contained MES buffer (10mM, pH 6.0) to which various NaCl or KCl  
20 concentrations were added. Currents were recorded with an Axopatch<sup>TM</sup> 200 amplifier. The electrical potential between the two chambers could be manipulated between  $\pm$ 200mV (TRANS relative to grounded CIS). Aliquots containing Vpu were added to the CIS chamber either as a detergent solution or after incorporation of the protein into phospholipid vesicles. The chamber was stirred until currents were observed.

25

### EXAMPLE 7

#### TESTING THE EFFECT OF HMA AND DMA ON HIV REPLICATION IN HUMAN MONOCYTES AND MACROPHAGES

30 Human monocytes were isolated from peripheral blood and cultured either for 24hr (one day old monocytes) or for 7 days to allow differentiation into monocyte derived macrophages

(MDM). These cells were then exposed to cell-free preparations of HIV isolates and allowed to absorb for 2hr before complete aspiration of the medium, washing once with virus-free medium and resuspension in fresh medium. The cells were exposed to 50-10 $\mu$ M HMA or DMA either 24 hr prior to infection or after infection. Subsequent HIV replication, at 5 various times after infection, was compared in cells exposed to drugs and in cells not exposed to drugs (controls). The progression and extent of viral replication was assayed using either an HIV DNA PCR method (Fear *et al*, 1998) or an ELISA method to quantitate p24 in culture supernatants (Kelly *et al*, 1998).

10

### EXAMPLE 8

#### EXPRESSION AND PURIFICATION OF VPU IN E. COLI

The plasmid p2GEXVpu (Fig. 1) was constructed to create an in-frame gene fusion between the GST and Vpu open-reading frames. This system enabled IPTG-inducible expression of 15 the Vpu polypeptide fused to the C-terminus of GST and allowed purification of the fusion protein by affinity chromatography on glutathione agarose.

Optimal levels of GST-Vpu expression were obtained by growing the cultures at 30°C to a cell density of approximately 250-300 Klett units and inducing with low levels of IPTG 20 (0.01mM). To purify the GST-Vpu, a combined cellular fraction containing the cell debris and plasma membrane was prepared by lysozyme treatment of the induced cells followed by a low-speed centrifugation. Approximately 50% of the GST-Vpu protein could be solubilised from this fraction using the zwitterionic detergent CHAPS. Affinity chromatography using glutathione-agarose beads was used to enrich the fusion protein and 25 thrombin was used to cleave the fusion protein at the high affinity thrombin site between the fusion partners, liberating Vpu (Fig. 2A). In fractions eluted from the anion exchange column Vpu was the major protein visible on silver stained gels (Fig. 2B, lane 1). Finally, Vpu was purified to apparent homogeneity on an immunoaffinity column (Fig. 2B, lane 2). The N-terminal amino acid sequence of the protein band (excised from SDS-PAGE gels) 30 corresponding to the immunodetected protein confirmed its identity as Vpu.

### EXAMPLE 9

#### VPU FORMS ION CHANNELS IN LIPID BILAYERS

To assay for ion-channel formation by Vpu, reconstitution into planar lipid bilayers was performed. When samples (containing between 7 and 70ng of protein) of purified recombinant Vpu were added to the 1ml of buffer in the CIS chamber of the bilayer apparatus, current fluctuations were detected after periods of stirring that varied from 2 to 30 min (Fig. 3). This time taken to observe channel activity approximately correlated with the amount of protein added to the chamber. No channels were detected when control buffer aliquots or control lipid vesicles were added to the CIS chamber. In those control experiments the chambers could be stirred for more than an hour without appearance of channel activity.

### EXAMPLE 10

#### PROPERTIES OF THE VPU CHANNELS

Channel activity was observed in over 40 individual experiments with Vpu samples prepared from five independent purifications. In different experiments, the amplitude of the currents varied over a large range and, again, seemed to approximately correlate with the amount of protein added. The smallest and largest channels measured had conductances of 14 pS and 280 pS, respectively. The channels were consistently smaller when lipid vesicles containing Vpu were prepared and fused to the bilayer rather than when purified protein in detergent solution was added. This may be because the former method included treatment with high concentrations of detergent and a dilution step that may have favoured the breakdown of large aggregates into monomers.

The relationship between current amplitude and voltage was linear and the reversal potential in solutions containing a ten-fold gradient of NaCl (500mM CIS; 50mM TRANS) was +30mV (Fig. 3B). A similar reversal potential was obtained when solutions contained KCl instead of NaCl. In 5 experiments with either NaCl or KCl in the solutions on either side of the membrane, the average reversal potential was  $31.0 \pm 1.2\text{mV}$  ( $\pm\text{SEM}$ ). This is more

- 37 -

negative than expected for a channel selectively permeable for the cations alone. Using ion activities in the Goldman-Hodgkin-Katz equation gives a  $P_{Na}/P_{Cl}$  ratio of about 5.5 indicating that the channels are also permeable to chloride ions. An attempt was made to reduce the anion current by substituting phosphate for chloride ions. When a Na-phosphate gradient  
5 (150mM  $Na^+$  & 100mM phosphate CIS; 15mM  $Na^+$  & 10mM phosphate TRANS, pH 6.8) was used instead of the Na Cl gradient, the reversal potential was  $37.1 \pm 0.2$  ( $\pm$ SEM,  $n=2$ ) again indicating a cation/anion permeability ratio of about 5. (For calculations involving the phosphate solutions, the summed activities of the mono and bivalent anions were used and it was assumed that the two species were equally permeable). The current-voltage curve now  
10 exhibited rectification that was not seen in the NaCl solutions. It can be concluded that the channels formed by Vpu are equally permeable to  $Na^+$  and  $K^+$  and are also permeable, though to a lesser extent, to chloride as well as phosphate ions.

### EXAMPLE 11

#### 15 BIO-ASSAY FOR SCREENING POTENTIAL ION-CHANNEL BLOCKING DRUGS

As part of a search for drugs that block the Vpu ion channel, a novel bio-assay was developed to facilitate the screening process which would be prohibitively slow if performed  
20 in the bilayer assay (Ewart *et al*, 1996). This bio-assay is based on the observation that expression of Vpu in *E.coli* results in an active Vpu channel located in the plasmalemma that dissipates the transmembrane sodium gradient. As a consequence of this Vpu channel activity, metabolites whose accumulation within the cells is mediated by a sodium dependent co-transporter (for example proline or adenine) leak out of the cell faster than they can be  
25 synthesised so that the metabolites' intracellular levels become limiting for growth of the cell. Thereby, an *E.coli* cell expressing Vpu is unable to grow in minimal drop-out media lacking adenine or proline. However, in the presence of a drug that blocks the Vpu channel, the cell is once again able to re-establish its transmembrane sodium gradient - due to the action of other ion pumps in the membrane - and the leakage of metabolites is prevented  
30 enabling growth. Experiments to demonstrate that Vpu can form sodium channels in the plasma membrane of *E.coli* were performed as follows:

To express unfused Vpu in *E. coli*, the vpu open-reading frame was cloned into the plasmid pPL451 (19) to create the recombinant plasmid pPL-Vpu (Fig. 1b). In this vector the strong  $P_L$  and  $P_R$  lambda promoters are used to drive expression of Vpu under control of the temperature sensitive cI857 repressor, such that when grown at 30°C expression is tightly repressed and can be induced by raising the temperature to between 37°C and 42°C. On agar plates, cells containing pPL-Vpu grew when incubated at 30°C and 37°C but not at 42°C, while control strains grew well at 42°C. Liquid cultures of cells containing pPL-Vpu were grown at 30°C to  $OD_{600}=0.84$  then moved to grow at 42°C for two hours (the final cell density was  $OD_{600}=0.75$ ). The plasma membrane fraction was prepared and western blotting, using an antibody that specifically binds to the C-terminus of Vpu, detected a single band at approximately 16kDa, indicating that Vpu was expressed and associated with the membranes (Fig. 2A, lane 5).

## EXAMPLE 12

### CROSS-FEEDING EXPERIMENTS REVEAL THAT PROLINE LEAKS OUT OF CELLS EXPRESSING VPU

Uptake of proline by *E. coli* is well characterised and active transport of the amino acid into the cells is known to use the sodium gradient as the energy source (Yamato *et al*, 1994). To detect whether proline leakage occurs, the following cross-feeding assay was used: A lawn of an *E. coli* strain auxotrophic for proline and methionine ( $Met^- Pro^-$ ), was seeded and poured as a soft agar overlay on minimal drop-out media plates lacking proline but containing methionine. Sterile porous filter discs were inoculated with a  $Met^+ Pro^+$  strain (XL-1 blue) containing either the pPL451 control plasmid or pPL-Vpu and placed onto the soft agar. The plates were then incubated at 37°C or 30°C for two days. After that time a halo growth of the  $Met^- Pro^-$  strain was clearly visible surrounding the disc inoculated with the cells containing pPL-Vpu incubated at 37°C (Fig. 4A). This growth can only be due to the leakage of proline from the Vpu-expressing cells on the disc. No such leakage was apparent from the control strain at 37°C nor around either strain on plates grown at 30°C (Fig. 4B).

In contrast to proline transport, the *E.coli* methionine permease is known to belong to the ABC transporter family (Rosen, 1987) and hence be energised by ATP. Identical cross-feeding experiments to those described above were set up except that the Met<sup>-</sup> Pro<sup>-</sup> strain was spread on minimal drop-out plates lacking methionine but containing proline. No growth  
5 of this strain was evident around any of the discs (Fig. 4C), indicating that methionine was not leaking out of the XL-1 blue cells even when Vpu was being expressed.

### EXAMPLE 13

#### 10 *E. COLI* CELLS EXPRESSING VPU REQUIRE ADENINE IN THE EXTERNAL MEDIUM FOR GROWTH

It was observed that, due to an uncharacterised mutation in the adenine synthesis pathway, growth of *E.coli* cells of the XL1-blue strain expressing Vpu at 37°C was dependant on the presence of adenine in the medium. This allowed the development of an even simpler bio-  
15 assay for Vpu ion-channel activity than the proline cross-feeding assay described above: A lawn of XL1-blue cells containing the pPL-Vpu plasmid is seeded onto an agarose plate lacking adenine in the medium, small aliquots of drugs to be tested for inhibition of the Vpu channel are spotted onto the agarose in discrete locations and the plates are incubated at 37°C for a suitable period of time (12-36 hours). Halos of growth around a particular drug  
20 application site indicate that the drug has inhibited expression of the Vpu ion channel activity that prevents growth in the absence of the drug.

### EXAMPLE 14

#### 25 THE BIOASSAY REVEALS 5-(N,N-HEXAMETHYLENE)-AMILORIDE AS A POTENTIAL CHANNEL BLOCKER

Using this assay, a number of amantadine derivatives were tested but found not to affect channel activity. However, when a number of amiloride derivatives were also tested, a halo of growth around the site of application of 5-(N,N-Hexamethylene)-Amiloride (HMA)  
30 identified this drug as a potential Vpu channel blocker (Fig. 5). Unsubstituted amiloride did not produce a halo of bacterial growth on these plates.



**EXAMPLE 15****PLANAR LIPID BILAYER EXPERIMENTS CONFIRM HMA AS A VPU  
CHANNEL INHIBITOR**

5 Inhibition of the Vpu ion-channel activity by HMA was confirmed in planar lipid bilayer experiments (Fig. 6), where concentrations of 50-250 $\mu$ M HMA were found to block ion flow through the channel. The parent compound, amiloride, and another derivative, 5-(N,N-Dimethyl)-Amiloride (DMA), were similarly tested in planar lipid bilayer experiments: DMA was found to inhibit channel activity, though not as potently as HMA. Amiloride  
10 itself was not active as a channel blocker at these concentrations.

**EXAMPLE 16****HMA AND DMA INHIBIT HIV-1 REPLICATION IN HUMAN MONOCYTES  
AND MACROPHAGES**

15

Subsequent tests were carried out to establish whether there was any anti-viral activity of HMA and DMA. Two tests were performed to characterise the effects of the drugs on HIV replication in human monocytes and macrophages: a) A PCR based assay was used to detect newly synthesised DNA arising from reverse transcription of the HIV genome, an early  
20 stage in virus replication; b) An ELISA method was used to quantitate production of the viral protein p24, reflecting a later stage in the replication process. Results of the PCR assay indicated that DMA at 50 $\mu$ M inhibited synthesis of HIV DNA in the cells; HMA was toxic to the cells at 50 $\mu$ M - further tests are being carried out at lower concentrations of this drug. p24 ELISA results indicated a clear inhibition of HIV virion synthesis with both DMA  
25 (50 $\mu$ M, data not shown) and also with HMA (Fig. 7), when used at non-toxic levels (10 $\mu$ M); Fig. 7A shows the effect of HMA on monocytes, Fig. 7B shows the effect of HMA on macrophages.

Those skilled in the art will appreciate that the invention described herein is susceptible to  
30 variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications. The invention also includes

all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations of any two or more of said steps or features.

**BIBLIOGRAPHY**

- Barry , M., Mulcahy, F. and Back, D.J., *Br J Clin Pharmacol*, **45**: 221-8. (1998)
- Deeks, S.G., *West J Med*, **168**:133-9. (1998)
- Miles, S.A., *J Acquir Immune Defic Syndr Hum Retrovirol*, **16 Suppl 1**: S36-41. (1997)
- Miles, S.A., *J. Acquir Immune Defic Syndr Hum Retrovirol*, **16 Suppl 1**: S1-2. (1998)
- Moyle, G.J., Gazzard, B.G., Cooper, D.A. and Gatell, J., *Drugs*, **55**:383-404. (1998)
- Rachlis, A.R. and Zarowny, D.P., *Cmaj*, **158**:496-505. (1998)
- Vella, S., Fragola, V. and Palmisano, L., *J Biol Regul Homeost Agents*, **11**:60-3. (1997)
- Volberding, P.A. and Deeks, S.G., *Jama*, **279**:1343-4. (1998)
- Volberding, P.A., *Hosp Pract (Off Ed)*, **33**:81-4, 87-90, 95-6 passim. (1998)
- Miller, R.H. and Sarver, N., *Nat Med*, **3**:389-94. (1997)
- Mitsuya, H., *Enzyme Inhibition*, **6**:1-8. (1992)
- Moore, J.P., *Science*, **276**:51-2. (1997)
- Thomas, M. and Brady, L., *Trends Biotechnol.*, **15**:167-72. (1997)
- Balliet, J.W., Kolson, D.L., Eiger, G., Kim, F.M., McGann, K.A., Srinivasan, A. and Collman, R., *Virology*, **200**:623-31. (1994)

- Westervelt, P., Henkel, T., Trowbridge, D.B., Orenstein, J., Heuser, J., Gendelman, H.E. and Ratner, L., *J Virol*, **66**:3925-31. (1992)
- Ewart, G.D., Sutherland, T., Gage, P.W. and Cox, G.B., *J Virol*, **70**:7108-7115. (1996)
- Schubert, U., Henklein, P., Boldyreff, B., Wingender, E., Strebel, K. and Porstmann, T., *J Mol Biol*, **236**:16-25. (1994)
- Friberg, J., Ladha, A., Gottlinger, H., Haseltine, W.A. and Cohen, E.A., *Journal of Acquired Immune Deficiency Syndromes & Human Retrovirology*, **8**:10-22. (1995)
- Love, C.A., Lilley, P.E. and Dixon, N.E., *Escherichia coli. Gene*, in press. (1996)
- Yamato, I., Kotani, M., Oka, Y. and Anraku, Y., *Escherichia coli. Journal of Biological Chemistry*, **269**:5729-5724. (1994)
- Rosen, B.R., *ATP-coupled solute transport systems. Escherichia coli and Salmonella typhimurium: Cellular and molecular biology 1*: (1987) Editor: Neidhardt, F.C. American Society for Microbiology.
- Piller, S.C., Ewart, G.D., Premkumar, A., Cox, G.B. and Gage, P.W., *Proceedings of the National Academy of Sciences of the United States of America*, **93**:111-115. (1996)
- Lu, Y.A., Clavijo, P., Galantino, M., Shen, Z.Y., Liu, W. and Tam, J.P., *Molecular Immunology*, **28**:623-630. (1991)
- Harlow, E. and Lane, D., (1988) *Antibodies: A laboratory manual*. (ed). Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y., 'Vol:'.
- Varadhachary, A. and Maloney, P.C., *Molecular Microbiology*, **4**:1407-1411. (1990)

New, R.C.C., (1990). Liposomes: A practical approach. *The Practical Approach Series*. Rickwood, D., Hames, B.D. (eds). IRL Press, Oxford, pages,

Miller, C., (1986) Ion channel reconstitution. (ed). Plenum Press, New York and London, 'Vol:'.

Fear, W.R., Kesson, A.M., Naif, H., Lynch, G.W. and Cunningham, A.L., *J. Virol*, **72**:1334-1344. (1998)

Kelly, M.D., Naif, H., Adams, S.L., Cunningham, A.L. and Lloyd, A.R., *J. Immunol*, **160**:3091-3095. (1998)

New, R.C.C. (ed.), Liposomes: a practical approach. IRL Press, Oxford (1990)

Grice, A.L., Kerr, I.D. and Sansom, M.S., *FEBS Lett*, **405**(3):299-304 (1997)

Moore, P.B., Zhong, Q., Husslein, T. and Klein, M.L., *FEBS Lett*, **431**(2):143-148 (1998)

Schubert, U., Bour, S., Ferrermontiel, A.V., Montal, M., Maldarelli, F. and Strebel, K., *Journal of Virology*, **70**(2):809-819 (1996a)

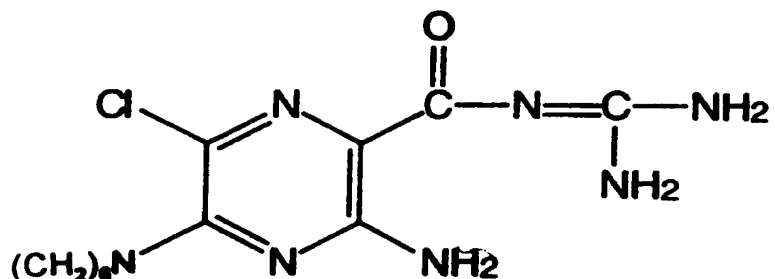
Willbold, D., Hoffmann, S. and Rosch, P., *Eur J Biochem*, **245**(3):581-8 (1997)

Wray, V., Kinder, R., Federau, T., Henklein, P., Bechinger, B. and Schubert, U., *Biochemistry*, **38**(16):5272-82 (1999)

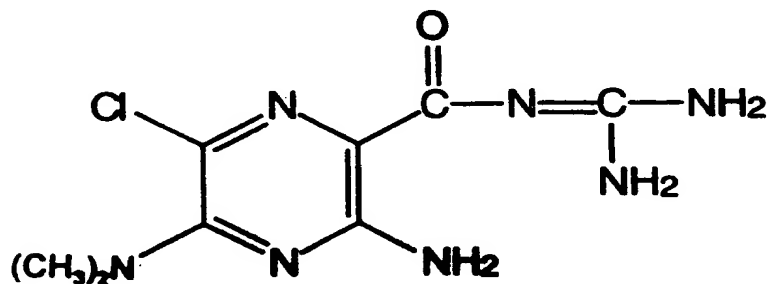
## CLAIMS:

1. A method of reducing, retarding or otherwise inhibiting the functional activity of HIV, which HIV has infected a mammalian host cell, said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate a membrane ion channel functional activity of said host cell.
2. The method according to claim 1 wherein said membrane ion channel is a Vpu ion channel.
3. The method according to claim 3 wherein said HIV functional activity is HIV replication.
4. The method according to claim 3 wherein said host cell is a macrophage.
5. The method according to claim 3 wherein said host cell is a monocyte.
6. The method according to any one of claims 1 to 5 wherein said agent is an amiloride analogue or functional equivalent thereof.
7. The method according to claim 6 wherein said amiloride analogue comprises a substitution of the amino group at the 5- position of the pyrazine ring of functional equivalent thereof.
8. The method according to claim 7 wherein said amiloride analogue is HMA or functional equivalent thereof.

9. The method according to claim 8 wherein said HMA comprise the structure:

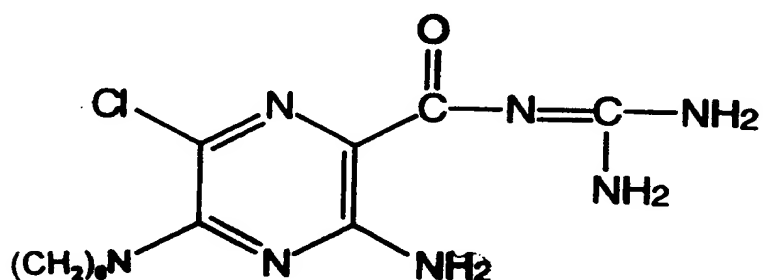


10. The method according to claim 7 wherein said amiloride analogue is DMA or functional equivalent thereof.
11. The method according to claim 10 wherein said DMA comprises the structure:

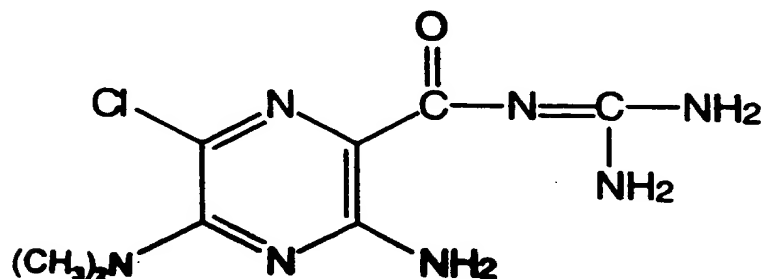


12. A method for the treatment and/or prophylaxis of HIV infection or AIDS in a mammal said method comprising administering to said mammal an effective amount of an agent for a time and under conditions sufficient to down-regulate the Vpu ion channel functional activity of an HIV infected mammalian host cell, wherein said Vpu functional activity reduces, retards or otherwise inhibits the functional activity of said HIV.
13. The method according to claim 12 wherein said HIV functional activity is HIV replication.
14. The method according to claim 13 wherein said host cell is a macrophage.

15. The method according to claim 14 wherein said host cell is a monocyte.
16. The method according to any one of claims 12 to 15 wherein said agent is an amiloride analogue or functional equivalent thereof.
17. The method according to claim 16 wherein said amiloride analogue comprises a substitution of the amino group at the 5- position of the pyrazine ring of functional equivalent thereof.
18. The method according to claim 17 wherein said amiloride analogue is HMA or functional equivalent thereof.
19. The method according to claim 18 wherein said HMA comprise the structure:



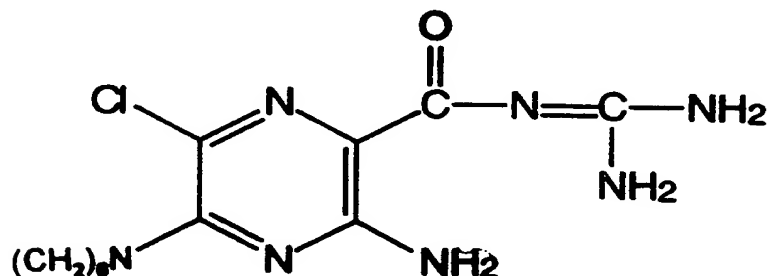
20. The method according to claim 17 wherein said amiloride analogue is DMA or functional equivalent thereof.
21. The method according to claim 20 wherein said DMA comprises the structure:





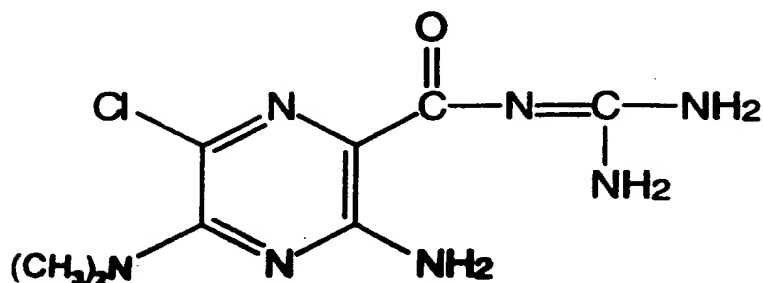
- 48 -

22. Use of an agent in the manufacture of a medicament for the therapeutic and/or prophylactic treatment of HIV infection and/or AIDS in a mammal which agent reduces, retards or otherwise inhibits the Vpu ion channel functional activity of an HIV infected cell.
23. Use according to claim 22 wherein said functional activity is the mediation of HIV replication.
24. Use according to claim 22 or 23 wherein said agent is an amiloride analogue or functional equivalent thereof.
25. Use according to claim 24 wherein said amiloride analogue comprises a substitution of the amino group at the 5- position of the pyrazine ring or functional equivalent thereof.
26. Use according to claim 25 wherein said amiloride analogue is HMA or functional equivalent thereof.
27. Use according to claim 26 wherein said HMA comprises the structure:

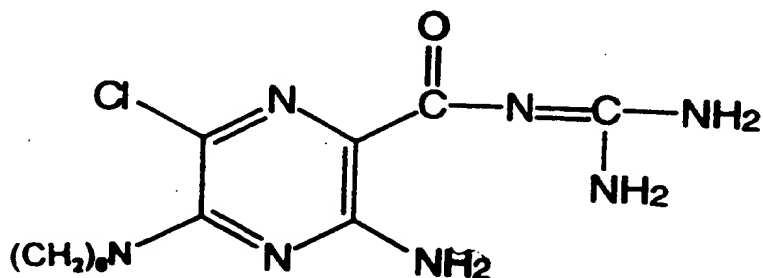


28. Use according to claim 25 wherein said amiloride analogue is DMA or functional equivalent thereof.

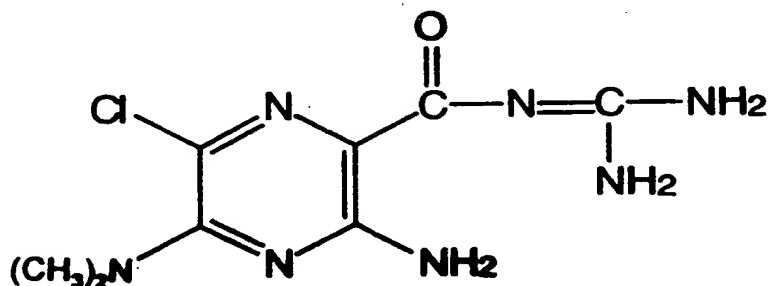
29. Use according to claim 28 wherein said DMA comprises the structure:



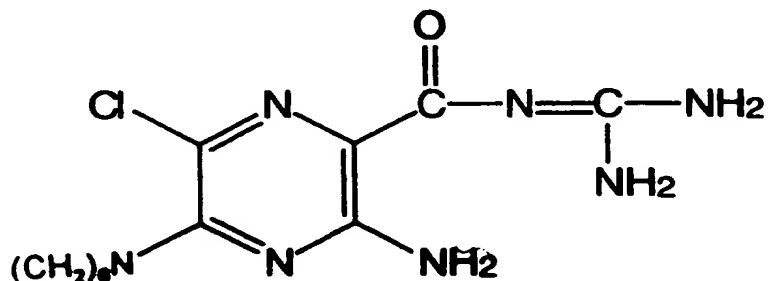
30. A method of reducing, retarding or otherwise inhibiting Vpu ion channel functional activity in a subject said method comprising administering to said subject an effective amount of an amiloride analogue or functional equivalent thereof for a time and under conditions sufficient to inhibit Vpu ion channel functional activity.
31. The method according to claim 30 wherein said Vpu ion channel functional activity is Vpu ion channel mediation of HIV replication.
32. The method according to any one of claims 30 or 31 wherein said amiloride analogue comprises a substitution of the amino group of the 5- position of the pyrazine ring or functional equivalent thereof.
33. The method according to claim 32 wherein said amiloride analogue is HMA or functional equivalent thereof.
34. The method according to claim 33 wherein said HMA comprises the structure:



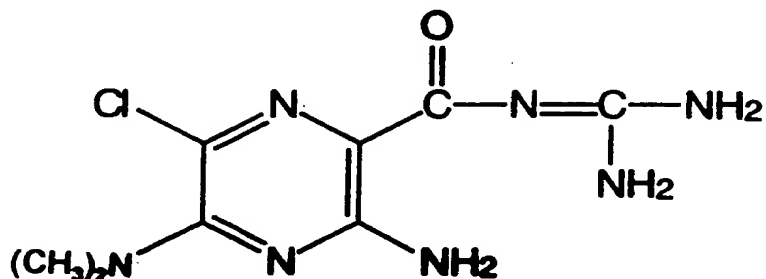
35. The method according to claim 32 wherein said amiloride analogue is DMA or functional equivalent thereof.
36. The method according to claim 35 wherein said DMA comprises the structure:



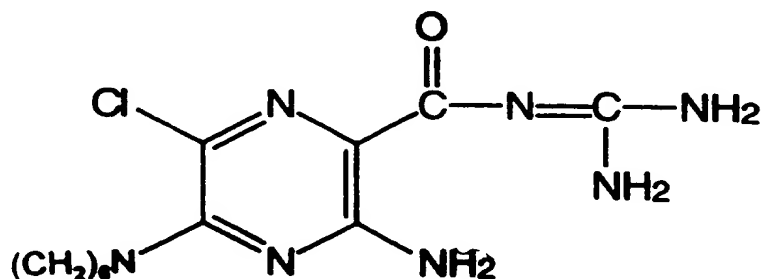
37. Agent for use in reducing, retarding or otherwise inhibiting Vpu ion channel functional activity.
38. The agent according to claim 37 wherein said Vpu ion channel functional activity is mediation of HIV replication.
39. The agent according to claim 38 wherein said agent is an amiloride analogue or functional equivalent thereof.
40. The agent according to claim 39 wherein said amiloride agent is HMA or functional equivalent thereof.
41. The agent according to claim 40 wherein said HMA comprises the structure:



42. The agent according to claim 39 wherein said amiloride agent is DMA or functional equivalent thereof.
43. The agent according to claim 42 wherein said DMA comprises the structure:

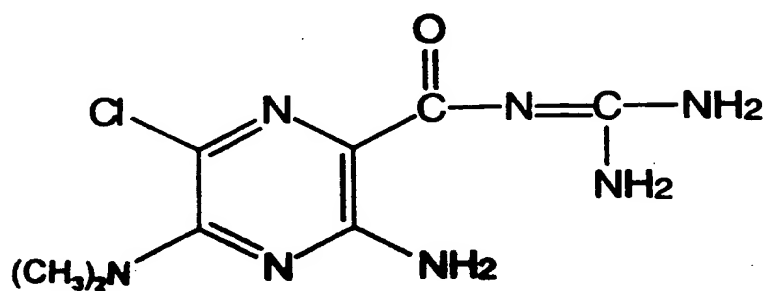


44. A pharmaceutical composition for use in reducing, retarding or otherwise inhibiting Vpu ion channel functional activity said composition comprising an agent as defined in accordance with any one of claims 1 to 21 and one or more pharmaceutical acceptable carriers and/or diluents.
45. The pharmaceutical composition according to claim 44 wherein said agent is an amiloride analogue or functional equivalent thereof.
46. The pharmaceutical composition according to claim 45 wherein said amiloride analogue is HMA or functional equivalent thereof.
47. The pharmaceutical composition according to claim 46 wherein said HMA comprises the structure:



- 52 -

48. The pharmaceutical composition according to claim 44 wherein said amiloride analogue is DMA or functional equivalent thereof.
49. The pharmaceutical composition according to claim 48 wherein said DMA comprises the structure:



1/10

10 \*  
 20 \*  
 30 \*  
 40 \*  
 50 \*  
 60 \*  
 70 \*  
 80 \*  
 \*  
 MQPIPIVAIVAVVVAIIIAIVVWSIVIIIEYRKILRQKIDRLIDRLIERAEDSGNESEGEISALVEMGVEMGHAPWDVDDL  
 \*

Figure 1a

2/10

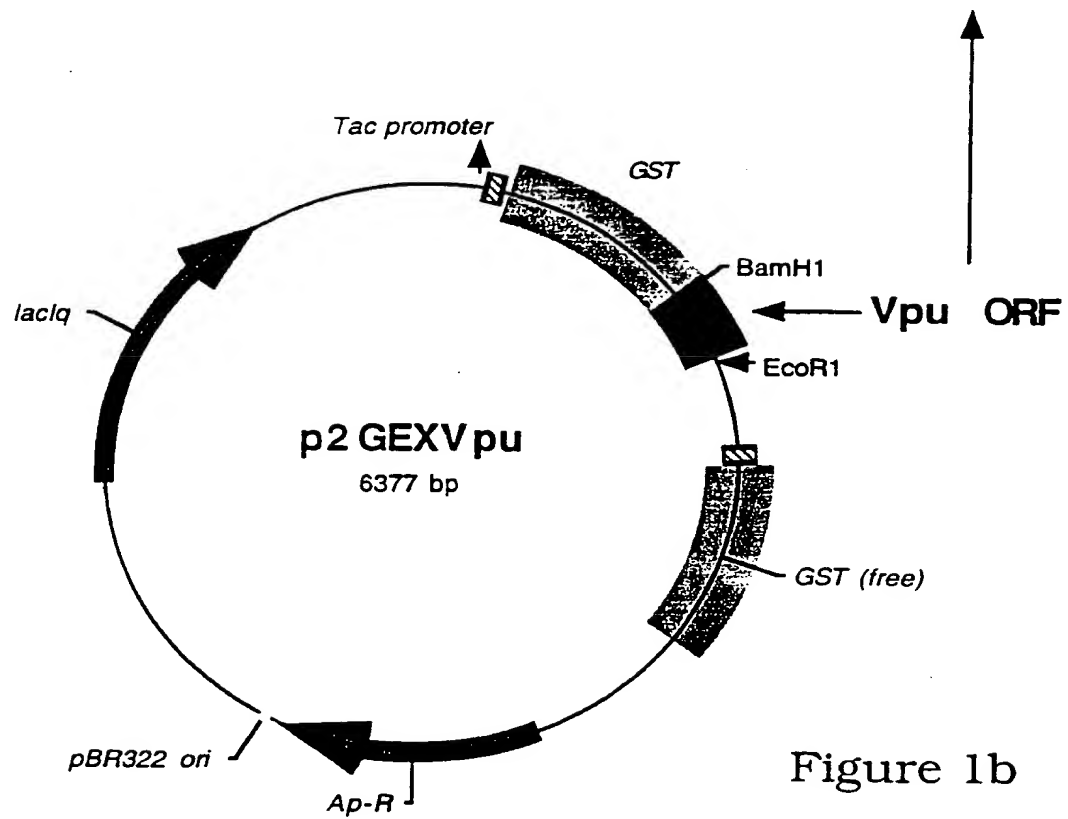


Figure 1b

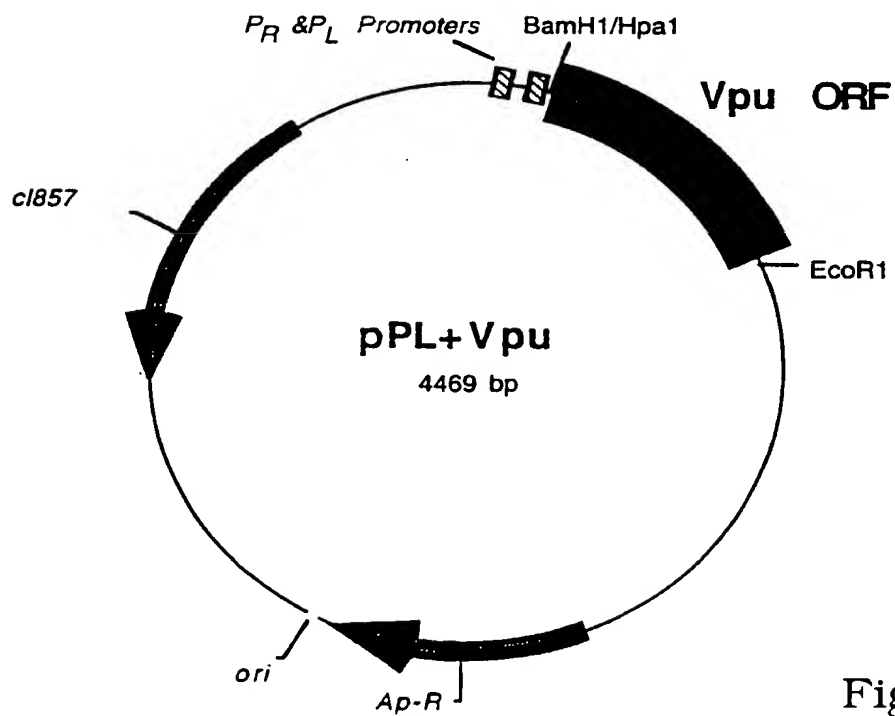


Figure 1c

3/10

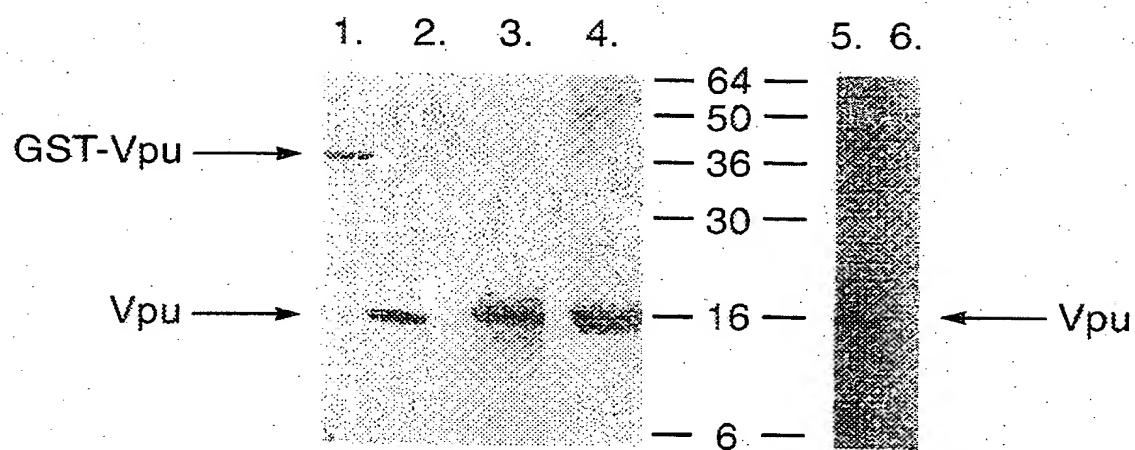


Figure 2a

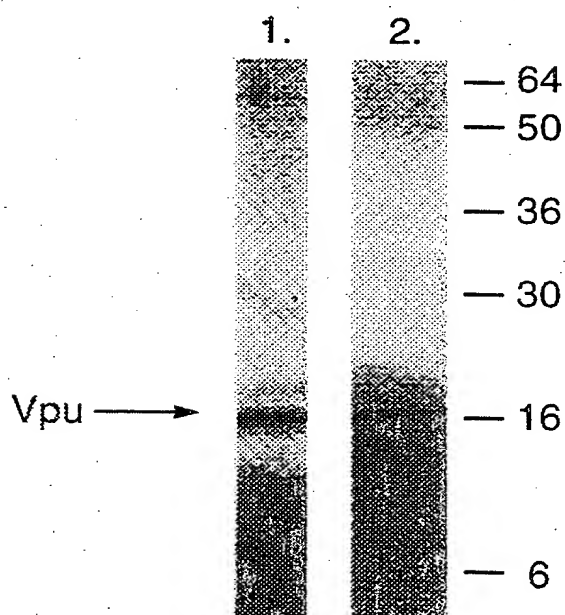


Figure 2b



4/10

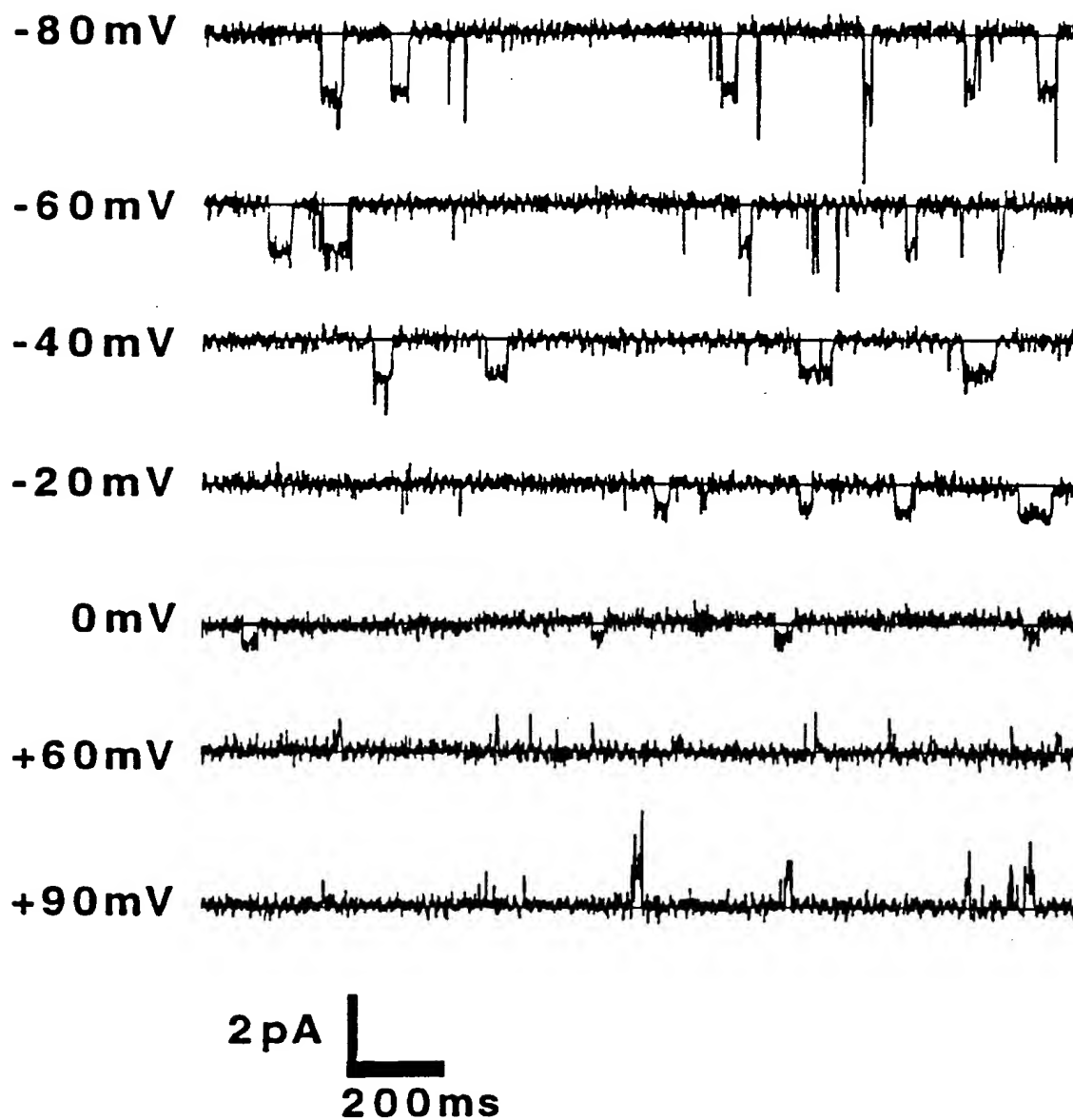


Figure 3a

5/10

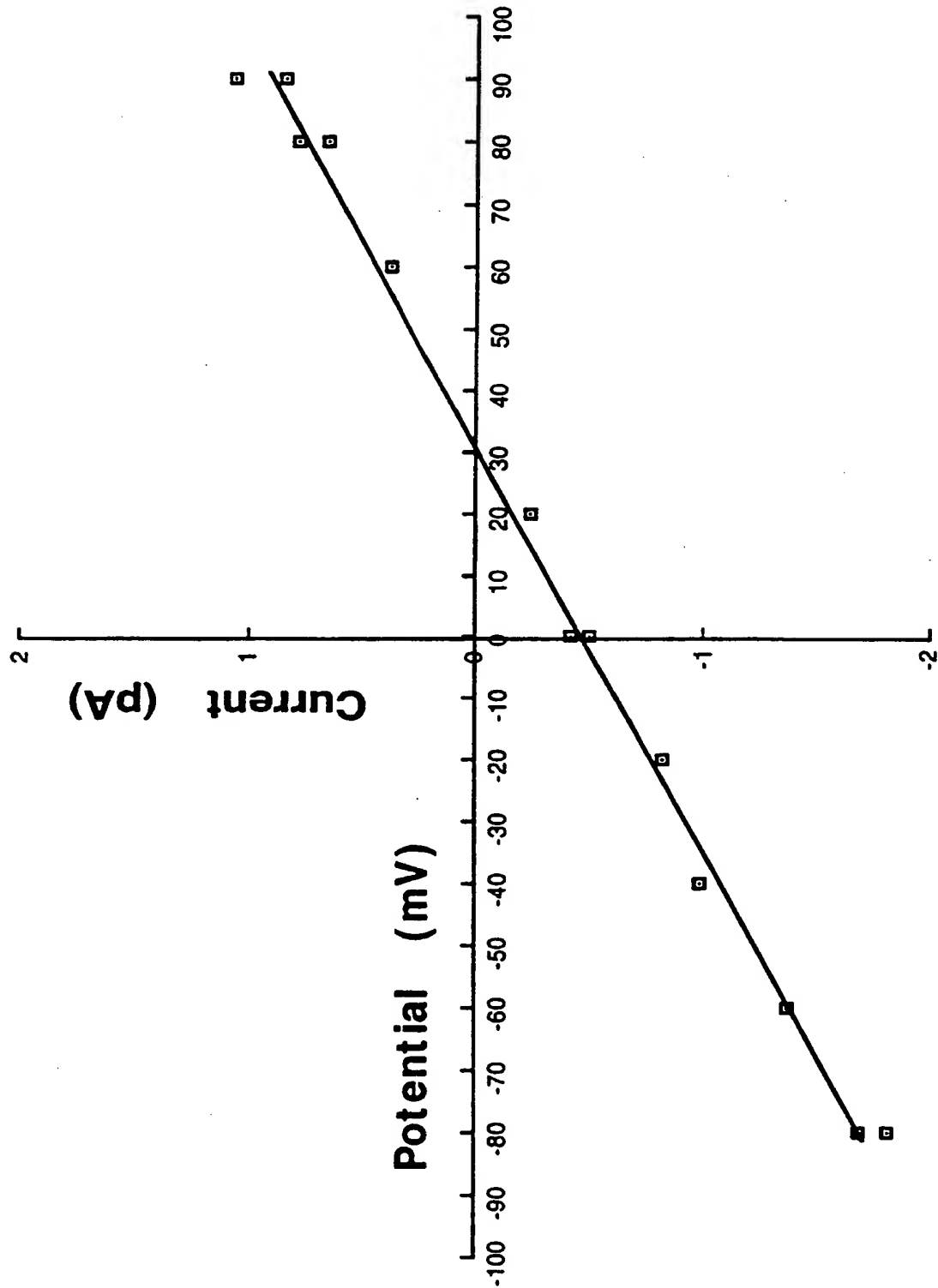


Figure 3b

6/10

Figure 4a

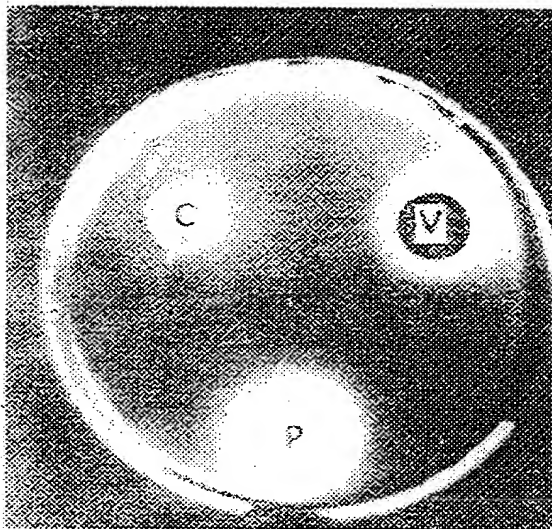
37°C, Pro<sup>-</sup> plate

Figure 4b

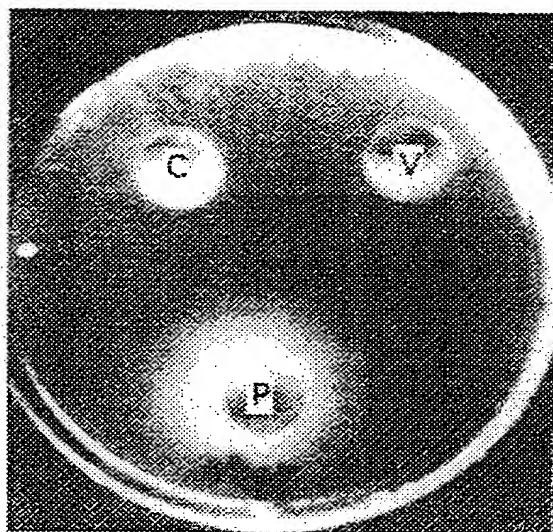
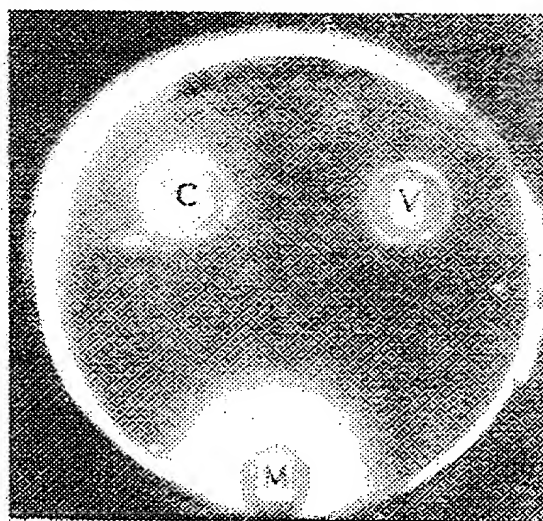
30°C, Pro<sup>-</sup> plate

Figure 4c

37°C, Met<sup>-</sup> plate

7/10

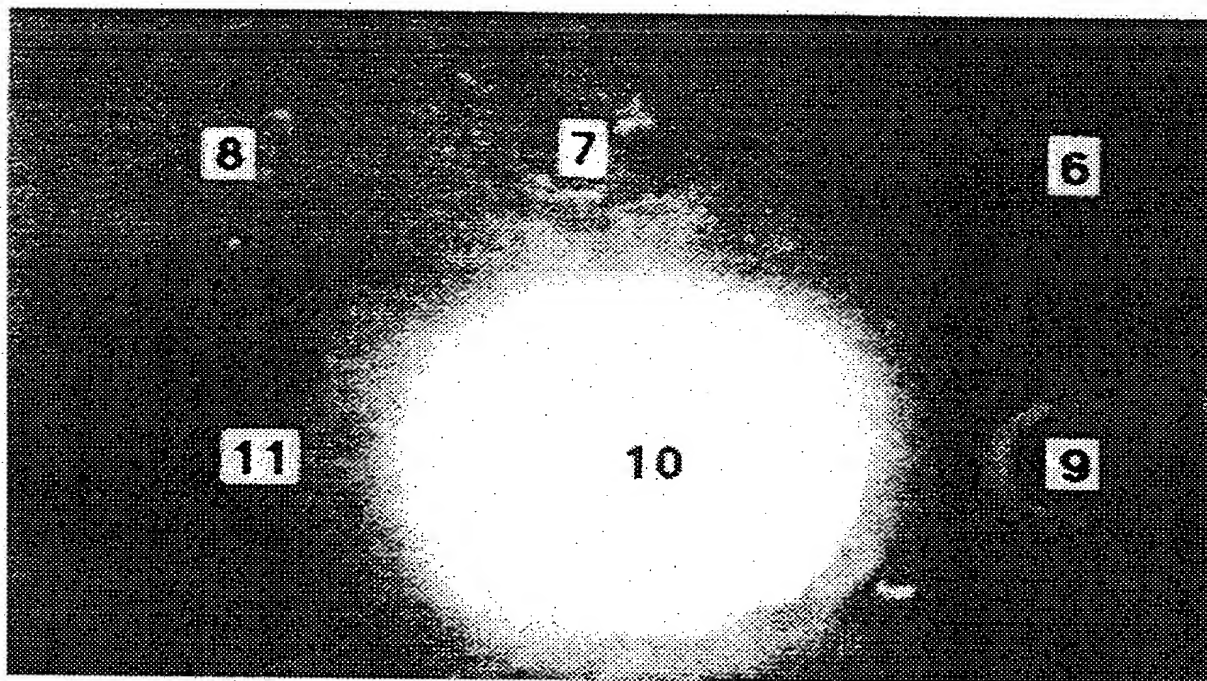


Figure 5

8/10

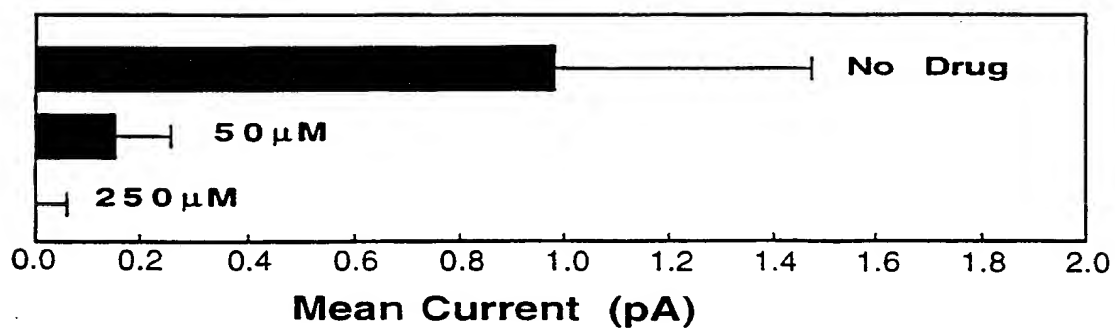
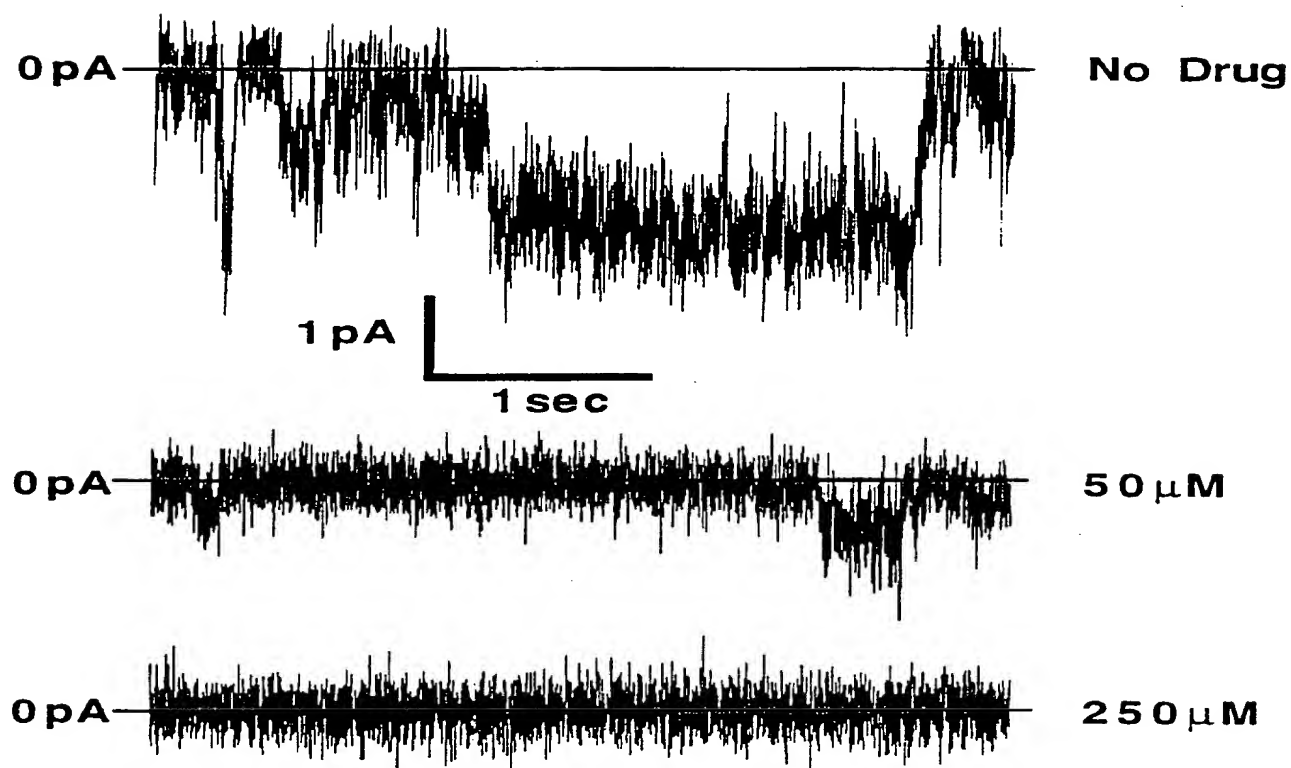
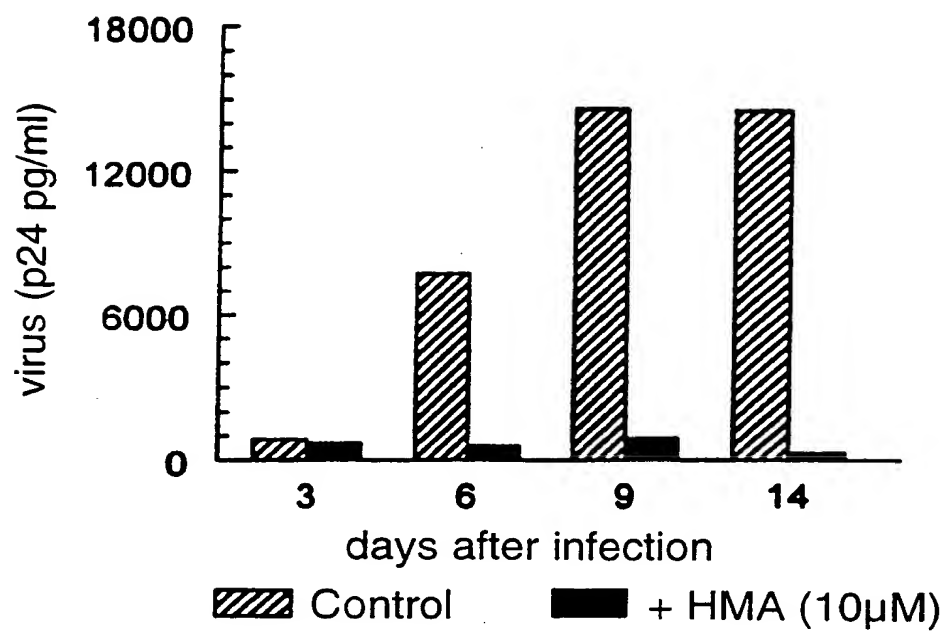


Figure 6

9/10

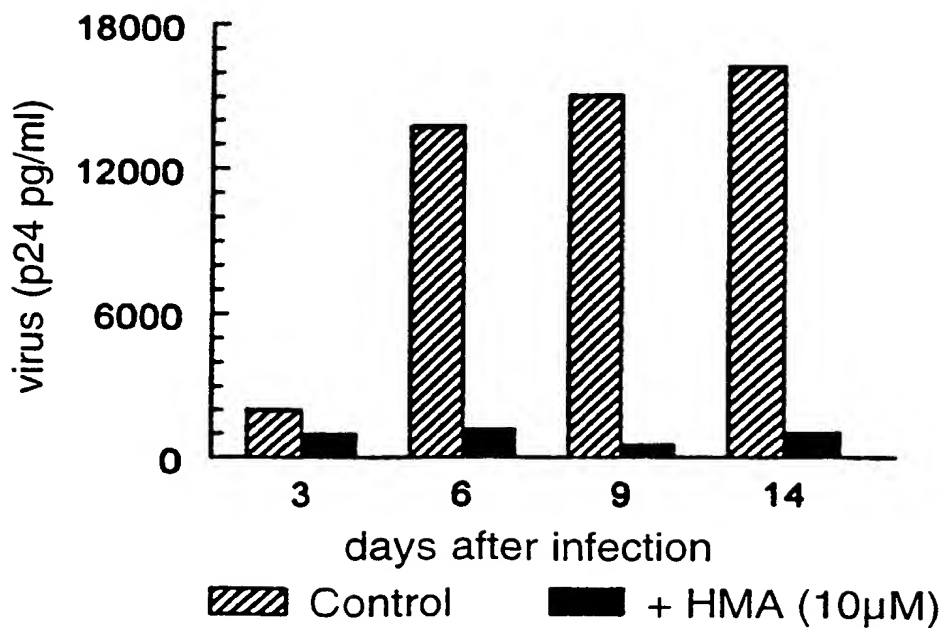
## Monocytes

Figure 7a



## Macrophages

Figure 7b



10/10

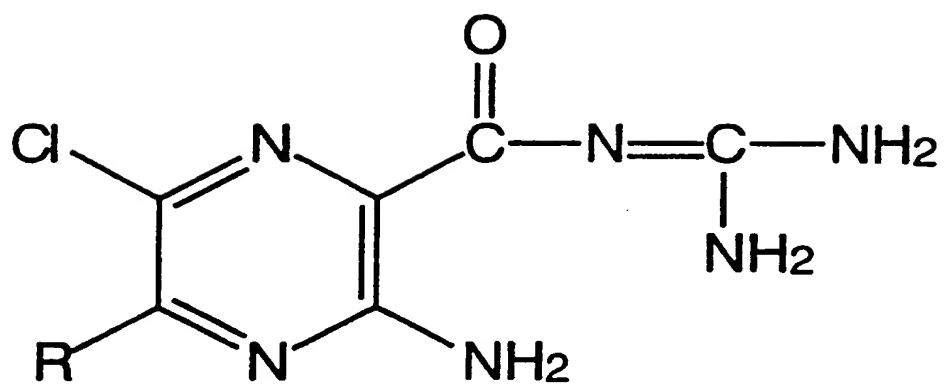


Figure 8

- 1 -

## SEQUENCE LISTING

&lt;110&gt; THE AUSTRALIAN NATIONAL UNIVERSITY

&lt;120&gt; A METHOD OF MODULATING ION CHANNEL FUNCTIONAL ACTIVITY

&lt;130&gt; 2222985/TDO

&lt;140&gt;

&lt;141&gt;

&lt;160&gt; 4

&lt;170&gt; PatentIn Ver. 2.0

&lt;210&gt; 1

&lt;211&gt; 82

&lt;212&gt; PRT

&lt;213&gt; HIV

&lt;400&gt; 1

Met Gln Pro Ile Pro Ile Val Ala Ile Val Ala Leu Val Val Ala Ile  
 1 5 10 15

Ile Ile Ala Ile Val Val Trp Ser Ile Val Ile Ile Glu Tyr Arg Lys  
 20 25 30

Ile Leu Arg Gln Arg Lys Ile Asp Arg Leu Ile Asp Arg Leu Ile Glu  
 35 40 45

Arg Ala Glu Asp Ser Gly Asn Glu Ser Glu Gly Glu Ile Ser Ala Leu  
 50 55 60

Val Glu Met Gly Val Glu Met Gly His His Ala Pro Trp Asp Val Asp  
 65 70 75 80

Asp Leu

&lt;210&gt; 2

&lt;211&gt; 24

&lt;212&gt; DNA

&lt;213&gt; HIV

&lt;400&gt; 2

agtaggatcc atgcaaccta tacc



- 2 -

<210> 3  
<211> 24  
<212> DNA  
<213> HIV

<400> 3  
tctggaattc tacagatcat caac

24

<210> 4  
<211> 21  
<212> PRT  
<213> HIV

<400> 4  
Cys Ala Leu Val Glu Met Gly Val Glu Met Gly His His Ala Pro Trp  
1 5 10 15

Asp Val Asp Asp Leu  
20

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/AU 99/00872

## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl<sup>6</sup>: A61K 31/495

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC A61K 31/495, C07D 241/32.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
AU :IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
Chemical Abstracts : Amiloride analog structures and (HIV or AIDS or HTLV or Vpu)  
WPAT ⊕A61K and amiloride)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Benos, Dale J et al Proc. Natl. Acad. Sci. USA Vol 91 pp 494-498, January 1994 "Envelope glycoprotein gp120 of human immunodeficiency virus type 1 alters ion transport in astrocytes: Implications for AIDS dementia complex."	
A	Schlanger, Lynn E. et al Kidney International Vol 45, (1994) pp 1070-1076 "K+-sparing diuretic actions of trimethoprim: Inhibition of Na+ channels in A6 distal nephron cells."	
A	Bubien, James K. et al Am J. Physiol. (1995), 286 (6, pt 1) C1440-C1449 1995. "HIV-gp 120 activates large-conductance apamin-sensitive potassium channels in rat astrocytes."	

☒ Further documents are listed in the continuation of Box C

☐ See patent family annex

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance  
"E" earlier application or patent but published on or after the international filing date  
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art  
"&" document member of the same patent family

Date of the actual completion of the international search  
13 December 1999

Date of mailing of the international search report  
17 DEC 1999

Name and mailing address of the ISA/AU  
AUSTRALIAN PATENT OFFICE  
PO BOX 200, WODEN ACT 2606, AUSTRALIA  
E-mail address: pct@ipaustalia.gov.au  
Facsimile No. (02) 6285 3929

Authorized officer

K. G. England  
Telephone No.: (02) 6283 2292

*K. G. England*

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 99/00872

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Makutonina, Alla et al Journal of Virology, Oct 1996, pp 7049-7055 Vol 70 No 10 "Human Immunodeficiency Virus Infection of T-Lymphoblastoid Cells Reduces Intracellular pH"	
A	Perazella, M.A. et al Clinical Nephrology Vol 476 No 3 - 1996 pp 187-192 "Trimethoprim-sulfamethoxazole hyperkalemia is an important complication regardless of dose."	

# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2222985/JMS/TDO/dk	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/AU 99/00872</b>	International filing date ( <i>day/month/year</i> ) 12 October 1999	(Earliest) Priority Date ( <i>day/month/year</i> ) 12 October 1998
Applicant The Australian National University		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☒ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (See Box II).

4. With regard to the **title**, ☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**, ☒ the text is approved as submitted by the applicant

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure

☐ because this figure better characterizes the invention

☒ None of the figures

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 99/00872

**A. CLASSIFICATION OF SUBJECT MATTER**Int Cl<sup>6</sup>: A61K 31/495

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
 IPC A61K 31/495, C07D 241/32.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
 AU :IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 Chemical Abstracts : Amiloride analog structures and (HIV or AIDS or HTLV or Vpu)  
 WPAT ⊕A61K and amiloride)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Benos, Dale J et al Proc. Natl. Acad. Sci. USA Vol 91 pp 494-498, January 1994 "Envelope glycoprotein gp120 of human immunodeficiency virus type 1 alters ion transport in astrocytes: Implications for AIDS dementia complex."	
A	Schlanger, Lynn E. et al Kidney International Vol 45, (1994) pp 1070-1076 "K+-sparing diuretic actions of trimethoprim: Inhibition of Na+ channels in A6 distal nephron cells."	
A	Bubien, James K. et al Am J. Physiol. (1995), 286 (6, pt 1) C1440-C1449 1995. "HIV-gp 120 activates large-conductance apamin-sensitive potassium channels in rat astrocytes."	

☒ Further documents are listed in the  
 continuation of Box C

☐ See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search  
 13 December 1999

Date of mailing of the international search report  
 17 DEC 1999

Name and mailing address of the ISA/AU  
 AUSTRALIAN PATENT OFFICE  
 PO BOX 200, WODEN ACT 2606, AUSTRALIA  
 E-mail address: pct@ipaustalia.gov.au  
 Facsimile No. (02) 6285 3929

Authorized officer

K. G. England  
 Telephone No.: (02) 6283 2292

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 99/00872

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Makutonina, Alla et al Journal of Virology, Oct 1996, pp 7049-7055 Vol 70 No 10 "Human Immunodeficiency Virus Infection of T-Lymphoblastoid Cells Reduces Intracellular pH"	
A	Perazella, M.A. et al Clinical Nephrology Vol 476 No 3 - 1996 pp 187-192 "Trimethoprim-sulfamethoxazole hyperkalemia is an important complication regardless of dose."	

## PCT REQUEST

2222985TDO

Original (for SUBMISSION) - printed on 12.10.1999 03:11:15 PM

<b>0</b>	<b>For receiving Office use only</b>	
<b>0-1</b>	International Application No.	
<b>0-2</b>	International Filing Date	
<b>0-3</b>	Name of receiving Office and "PCT International Application"	
<b>0-4</b>	<b>Form - PCT/RO/101 PCT Request Prepared using</b>	<b>PCT-EASY Version 2.84 (updated 01.07.1999)</b>
<b>0-5</b>	<b>Petition</b> The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
<b>0-6</b>	<b>Receiving Office (specified by the applicant)</b>	<b>Australian Patent Office (RO/AU)</b>
<b>0-7</b>	<b>Applicant's or agent's file reference</b>	<b>2222985TDO</b>
<b>I</b>	<b>Title of invention</b>	<b>A METHOD OF MODULATING ION CHANNEL FUNCTIONAL ACTIVITY</b>
<b>II</b>	<b>Applicant</b>	
<b>II-1</b>	This person is:	<b>applicant only</b>
<b>II-2</b>	Applicant for	<b>all designated States except US</b>
<b>II-4</b>	Name	<b>THE AUSTRALIAN NATIONAL UNIVERSITY</b>
<b>II-5</b>	Address:	<b>- Acton, Australian Capital Territory 2601 Australia</b>
<b>II-6</b>	State of nationality	<b>AU</b>
<b>II-7</b>	State of residence	<b>AU</b>
<b>II-8</b>	Telephone No.	<b>-</b>
<b>II-9</b>	Facsimile No.	<b>-</b>
<b>II-10</b>	e-mail	<b>-</b>
<b>III-1</b>	<b>Applicant and/or inventor</b>	
<b>III-1-1</b>	This person is:	<b>applicant and inventor</b>
<b>III-1-2</b>	Applicant for	<b>US only</b>
<b>III-1-4</b>	Name (LAST, First)	<b>COX, Graeme</b>
<b>III-1-5</b>	Address:	<b>66 Bundle Hill Road Bawley Point, New South Wales 2539 Australia</b>
<b>III-1-6</b>	State of nationality	<b>AU</b>
<b>III-1-7</b>	State of residence	<b>AU</b>

## PCT REQUEST

2222985TDO

Original (for SUBMISSION) - printed on 12.10.1999 03:11:15 PM

III-2	<b>Applicant and/or inventor</b>	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	EWART, Gary
III-2-5	Address:	189 Phillip Avenue Hackett, Australian Capital Territory 2602 Australia
III-2-6	State of nationality	AU
III-2-7	State of residence	AU
III-3	<b>Applicant and/or Inventor</b>	
III-3-1	This person is:	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	GAGE, Peter
III-3-5	Address:	130 Powell Drive Queanbeyan, New South Wales 2620 Australia
III-3-6	State of nationality	AU
III-3-7	State of residence	AU
IV-1	<b>Agent or common representative; or address for correspondence</b> The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	SLATTERY, John, M
IV-1-2	Address:	Davies Collison Cave 1 Little Collins Street Melbourne, Victoria 3000 Australia
IV-1-3	Telephone No.	+613 9254 2777
IV-1-4	Facsimile No.	+613 9254 2770
IV-1-5	e-mail	jslattery@davies.com.au
IV-2	<b>Additional agent(s)</b>	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	HUGHES, E, John, L; CAINE, Michael, J



## PCT REQUEST

2222985TDO

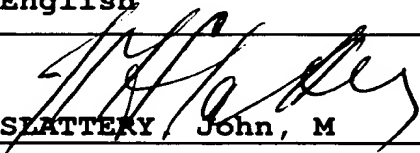
Original (for SUBMISSION) - printed on 12.10.1999 03:11:15 PM

<b>V</b>	<b>Designation of States</b>	
<b>V-1</b>	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	<p><b>AP:</b> GH GM KE LS MW SD SL SZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT</p> <p><b>EA:</b> AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT</p> <p><b>EP:</b> AT BE CH&amp;LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT</p> <p><b>OA:</b> BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT</p>
<b>V-2</b>	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	<p>AE AL AM AT AU AZ BA BB BG BR BY CA CH&amp;LI CN CR CU CZ DE DK DM EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW</p>
<b>V-5</b>	<b>Precautionary Designation Statement</b> In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
<b>V-6</b>	<b>Exclusion(s) from precautionary designations</b>	<b>NONE</b>
<b>VI-1</b>	<b>Priority claim of earlier national application</b>	
<b>VI-1-1</b>	Filing date	<b>12 October 1998 (12.10.1998)</b>
<b>VI-1-2</b>	Number	<b>PP6464</b>
<b>VI-1-3</b>	Country	<b>AU</b>
<b>VI-2</b>	<b>Priority document request</b> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	<b>VI-1</b>

## PCT REQUEST

2222985TDO

Original (for SUBMISSION) - printed on 12.10.1999 03:11:15 PM

VII-1	International Searching Authority Chosen	<b>Australian Patent Office (ISA/AU)</b>	
VIII	Check list	number of sheets	electronic file(s) attached
VIII-1	Request	<b>4</b>	-
VIII-2	Description (excluding sequence listing part)	<b>44</b>	-
VIII-3	Claims	<b>8</b>	-
VIII-4	Abstract	<b>1</b>	<b>2222985.txt</b>
VIII-5	Drawings	<b>8</b>	-
VIII-6	Sequence listing part of description	<b>2</b>	-
VIII-7	TOTAL	<b>67</b>	
VIII-8	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-15	Nucleotide and/or amino acid sequence listing in computer readable form		<b>separate diskette</b>
VIII-16	PCT-EASY diskette	-	<b>diskette</b>
VIII-18	Figure of the drawings which should accompany the abstract	-	
VIII-19	Language of filing of the international application	<b>English</b>	
IX-1	Signature of applicant or agent		
IX-1-1	Name (LAST, First)	<b>SLATTERY John, M</b>	

## FOR RECEIVING OFFICE USE ONLY

10-1	Date of actual receipt of the purported international application	
10-2	Drawings:	
10-2-1	Received	
10-2-2	Not received	
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	<b>ISA/AU</b>
10-6	Transmittal of search copy delayed until search fee is paid	

## FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	
------	--	--

15

CENT COOPERATION TREATY  
**PCT**  
INTERNATIONAL PRELIMINARY EXAMINATION REPORT

REC'D 04 SEP 2000

WIPO

PCT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 2222985/JMS/TDO/LMa	<b>FOR FURTHER ACTION</b>	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. <b>PCT/AU99/00872</b>	International filing date ( <i>day/month/year</i> ) 12 October 1999	Priority Date ( <i>day/month/year</i> ) 12 October 1998
International Patent Classification (IPC) or national classification and IPC  <b>Int. Cl. <sup>7</sup> A61K 31/4965, 31/497 A61P 31/18</b>		
Applicant The Australian National University, CAGE, Peter et al		

1.	This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2.	This REPORT consists of a total of 4 sheets, including this cover sheet.  <input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).  These annexes consist of a total of sheet(s).
3.	This report contains indications relating to the following items:  I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application

Date of submission of the demand 17 March 2000	Date of completion of the report 17 August 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer  <b>K. G. England</b> Telephone No. (02) 6283 2292

**I. Basis of the report****1. With regard to the elements of the international application:\***

- ☒ the international application as originally filed.
- ☐ the description,        pages , as originally filed,  
   pages , filed with the demand,  
   pages , received on    with the letter of
- ☐ the claims,                pages , as originally filed,  
   pages , as amended (together with any statement) under Article 19,  
   pages , filed with the demand,  
   pages , received on    with the letter of
- ☐ the drawings,            pages , as originally filed,  
   pages , filed with the demand,  
   pages , received on    with the letter of
- ☐ the sequence listing part of the description:  
   pages , as originally filed  
   pages , filed with the demand  
   pages , received on    with the letter of

**2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.**

These elements were available or furnished to this Authority in the following language which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

**3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, was on the basis of the sequence listing:**

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

**4. ☐ The amendments have resulted in the cancellation of:**

- ☐ the description,        pages
- ☐ the claims,            Nos.
- ☐ the drawings,        sheets/fig.

**5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\***

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

\*\* Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)	Claims 1 to 49	YES
	Claims Nil	NO
Inventive step (IS)	Claims 1 to 49	YES
	Claims Nil	NO
Industrial applicability (IA)	Claims 1 to 49	YES
	Claims Nil	NO

**2. Citations and explanations (Rule 70.7)**

Benos, Dale J. et al, Proc Natnl Acad Sci USA Vol 91 pp 494-498 (Jan 1994) "Envelope glycoprotein gp120 of human immunodeficiency virus type 1 alters ion transport in astrocytes: Implications for AIDS dementia complex."

Schlanger, Lynn E et al, Kidney International Vol 45 pp 1070 - 1076 (1994) "K<sup>+</sup> sparing diuretic actions of trimethoprim: Inhibition of Na<sup>+</sup> channels in distal nephron cells."

Bubien, James K., Am. J. Physiol. (1995) 286 (6, part 1) C1440-C1449 "HIV - gp120 activates large - conductance apamin sensitive potassium channels in rat astrocytes."

Makutonina, Alla et al, J Virol., Vol 70 (10) pp 7049-7055 (Oct 1996) : "Human Immunodeficiency Virus Infection of T - Lymphoblastoid Cells Reduces Intracellular pH."

Perezella M.A. et al, Clinical Nephrology, Vol 476 (3) pp 187-192 (1996) "Trimethoprim-sulfamethoxazole hyperkalemia is an important complication regardless of dose."

None of the documents disclose or fairly suggest that amiloride analogues inhibit the functional activity of human immunodeficiency virus in host cells. All claims are novel and have an inventive step in comparison.

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claim 3 is not clear because it is appended to itself.

Claims 6 and 30 are not clear. The scope of "a functional equivalent thereof" is uncertain when applied to amiloride analogues, and probably included amiloride itself.

The description at page 16 line 14 to page 22 line 6 suggests that peptides or peptide-like compounds may be suitable for inhibiting the activity of Vpu ion channels. However no specific compounds have been disclosed, nor have any general classes of peptides or peptide-like compounds been clearly suggested. Nor is there any suggestion of how such compounds may be developed. Discussion of such compounds in this application therefore appears to be speculation.

Since the only compounds disclosed to have the property of inhibition of Vpu ion channels are amiloride analogues, it appears that such analogues are essential to the invention. Therefore claims 1 to 5, 12 to 15, 22, 23, 37 and 38 which lack reference to amiloride analogues are not fully supported by the description.